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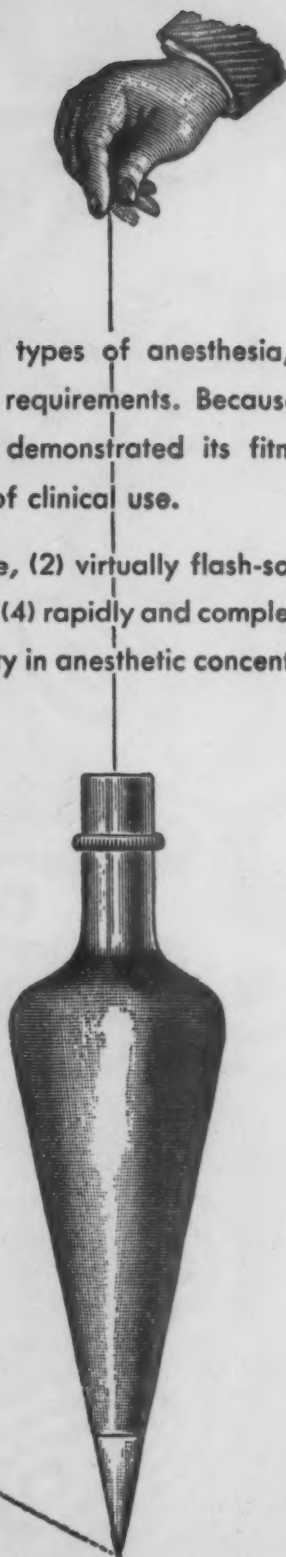
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VALVULAR ANASTOMOSIS OF THE HEART CAVITIES*

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THE BY-PASSING of a narrowed lumen is a well-known procedure in surgery. It is not surprising that many workers have tried to apply this principle in blood vessel and heart surgery. Although anastomoses between blood vessels have been created on a large scale, little has been done in the formation of anastomoses between the heart chambers.

Schepelmann¹ joined both auricular appendages of a rabbit's heart in order to relieve a stenosis of the tricuspid valve. He intended to lead the blood back into the right ventricle by means of an artificial opening in the septum between the ventricles.

Jeger² tried to by-pass a stenosed mitral valve using the following procedure. He ligated and dissected one left pulmonary vein, near the atrium, and joined the peripheral end of the vessel to a piece of jugular vein, so that the valves of the vein allowed the blood to flow from the lung to the heart. The other end of the jugular vein was implanted by means of a vitallium cannula into the left ventricle. The result was a great congestion in the corresponding lobe of the lung. The venous valves were seemingly incapable of resisting the pressure in the left ventricle, and a reversion of the circulation took place.

Jarotzky,³ basing his theory on the clinical observation of Lutembacher⁴ that patients suffering from mitral stenosis and patent foramen ovale are more resistant to strain and live longer than those with closed foramen ovale, proposed to slit the interauricular septum by introducing a cutting instrument through the right jugular vein into the right atrium. Dimitrieff⁵ perforated this septum, using the auricular appendage as a way of approach. This creation of an anastomosis between cavities of the venous (right) and the arterial (left) heart, however, could have experimental value by reproducing congenital lesions. Joining an atrium to its corresponding ventricle may have therapeutic importance in cases where the normal communications have undergone pathologic changes. Such an anastomosis would by-pass the obstacle and help restore the normal blood flow.

The direction of the flow in the blood vessels is maintained by a constant

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favorable difference of pressure, but in the heart chambers the direction is sustained by the heart valves. Thus an anastomosis between the corresponding heart cavities in order to maintain the physiologic direction of the blood stream *must* have valvular properties, because of the changing pressure in these cavities.

In the following described attempts to join right or left atrium to the corresponding ventricles, the valvular requirement was fulfilled by implanting the auricular appendage into the ventricular cavity.

The auricular appendage, as a part of the atrium, is in broad communication with the atrial cavity. The apex of the auricle points toward the ventricle, thus representing a short anatomical pathway for producing a connection between atrium and ventricle. The auricle, having a mesothelial lining inside and outside, is entirely suitable to be lodged in the ventricular cavity. Furthermore, because of its funnel-shaped structure, it can easily be transformed into a valve allowing the flow to pass from a broad base to a narrow apex, whereas back-flow will be difficult. Finally Allen and Graham,⁶ Cutler and Beck,⁷ Dimitrieff,⁵ Souttar,⁹ *et al.*, have shown that various operations on the auricular appendage do not appreciably affect the heart action.

The following technics have been established, using the appendage for anastomosing atrium and ventricle of the venous (right) and of the arterial (left) heart.

TECHNIC

Dogs were anesthetized with intravenous nembutal, and artificial respiration was administered by positive pressure through an endotracheal tube. The animal was placed on the right side, a small pad under the right thorax improving the exposure. The incision was made in the fourth intercostal space for the left auricle, the third intercostal space for the right. As a good practical rule, the incision for the venous heart should be made in the interspace where the heart beat is best felt on palpation, but the incision for the arterial heart, the left, should be made in the intercostal space below this. When the pleural cavity is opened, a tampon, soaked in 5 per cent cocaine solution, is used to paint the pericardium in order to block reflexes that might arise and disturb cardiac activity. Exposure is maintained by self-retaining rib-spreaders and towels packing off the lungs. A longitudinal incision is made in the pericardium between two holding sutures, which stretch and maintain the opening. The incision is carried up to the superior reflection of the pericardium. Cocaine solution (5 per cent) is introduced into the pericardial cavity and is spread over the epicardium by the heart contractions.

Preparation of the auricular appendage. The auricular appendage is gently grasped at its apex, and a narrow, angled, weak-jawed, rubber-jacketed clamp is fixed as close as possible to its base. The appendage can be opened on the anterior or the posterior surface by re-section of the tip or by bisecting it, everting the endocardial surface of the two resulting flaps. The current technic in preparation of the appendage has been to cut longitudinal openings

VALVULAR ANASTOMOSIS OF THE HEART CAVITIES

along its borders in order to create two flaps, joined at the tip, imitating the expiration rubber valve, and thus to obtain a valvular action (Fig. 1).

A suture is placed at the proximal limit of the openings, starting on the anterior surface of the appendage, stitching through its left margin, passing

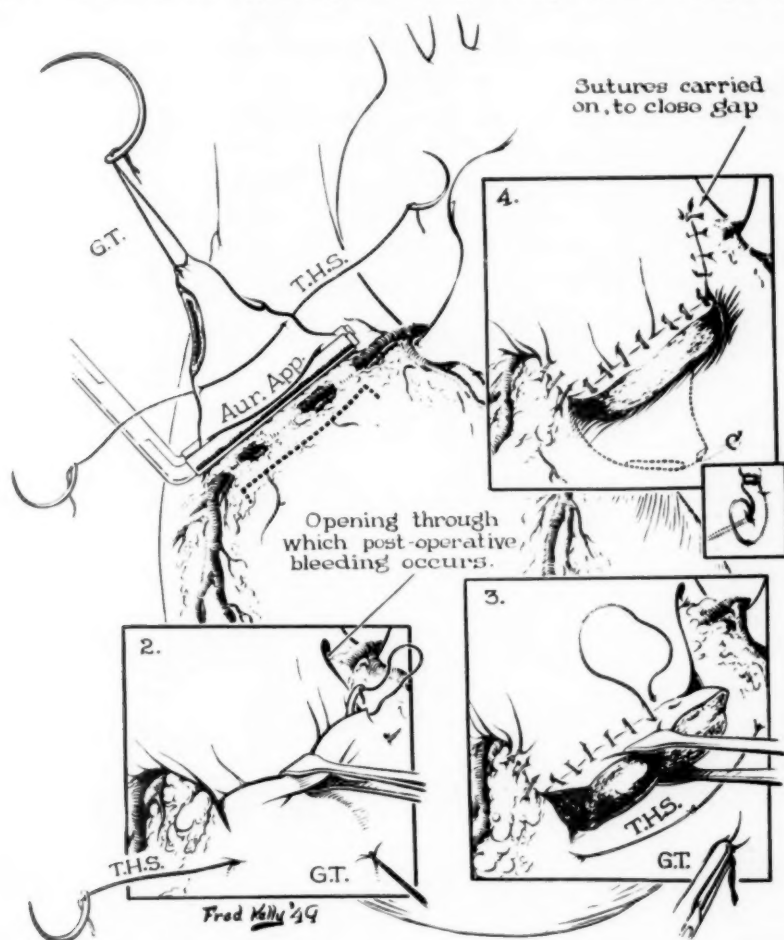


FIG. 1.—Right Atrio-Ventricular Anastomosis. (1) Preparation of the auricular appendage (Aur. App.) Guide thread (G.T.) and a temporary hemostatic sutures (T.H.S.) are placed. The dotted line marks the ventricular incision. (2) Appendage implanted and Allis forceps inserted. The temporary hemostatic suture is stitched through the ventricular myocardium. (3) Eversion of a myocardial flap. Running suture between epicardium and endocardium. The tied T.H.S. arrests hemorrhage. (4) The flap is partially resected and the epi-endocardial suture completed. The temporary hemostatic suture is withdrawn, but the guide-thread permanently fixed.

over the posterior surface and out through the right appendicular margin. The ends of this "temporary hemostatic suture" are threaded through No. 6 curved needles and clamped in needle-holders, ready for use. The "guide thread," a "oo" silk thread, is stitched through the tip of the appendage and threaded in a full curved No. 4 needle.

Opening the right ventricle. A transverse incision is to be made in the anterior ventricular wall, just at the inferior margin of the fatty tissue surrounding the coronary vessels. A pair of slightly curved and sharp-pointed scissors, with exterior cutting edges, and with a screw fixing the distance of spreading, are used for this purpose (Fig. 2). They are introduced, closed, into the ventricular cavity, serving as a leader along which the needle bearing the guide thread is passed through the anterior wall. At this moment the scissors are spread until arrested. They are then withdrawn, executing the incision by their sharp exterior edges.

FIG. 2

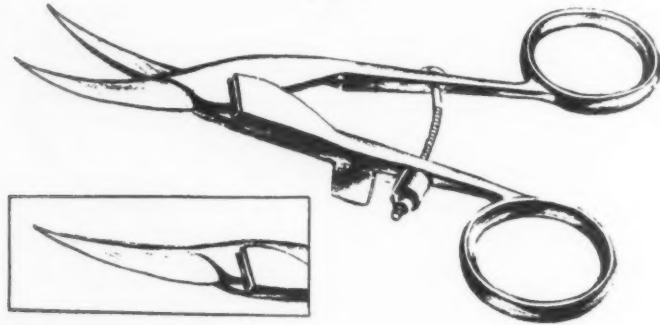


FIG. 3



FIG. 4

FIG. 2.—Special scissors having exterior cutting edges and the distance of spread fixed by a screw.

FIG. 3.—Local anesthesia at the base of the auricular appendage and behind the coronary vessels.

FIG. 4.—The coronary vessels are separated from the atrial wall by using blunt scissors.

The appendage is pulled in quickly by traction on the guide thread, diminishing the hemorrhage. The ends of the T.H.S. are stitched through the ventricular wall and tied 2 cm. below the incision, thus closing the space between appendage and ventricular wall. Hemorrhage is thereby arrested (Fig. 1).

An Allis forceps is inserted at the anterior lip of the incision. This everts the endocardium of a muscular flap which is then created by making two cuts through the myocardium, perpendicular to and at the ends of the original incision. A running suture joins the epicardium of the appendage to the endocardium of the ventricle and continues upward until the base of the auricle is reached. This sutures the margins of the appendage to the atrial epicardium and closes completely the space behind the appendage. The T.H.S. is cut and withdrawn. The guide thread is permanently fixed where it emerges. By this the appendage is held in the ventricle in a moderately stretched position favoring its valvular function (Fig. 1).

The implantation of the auricular appendage below the coronary vessels is the only procedure which can be used in the venous heart, the right heart. Using the same procedure in the arterial heart, the left, where the ventricular muscle is twice as thick, only the tip of the auricle would enter the left ventricle. But, as this apex is mainly of spongy muscular structure and unsuitable for a clear-cut communication, another procedure is required.

Left atrio-ventricular anastomosis, or the implantation of the left auricular appendage behind the coronary vessels. To implant the appendage in the ventricular cavity one can use the anterior wall of the ventricle, near the fibrous atrio-ventricular ring, which represents the sharp insertion-line of the valves, separating the ventricular cavity from the atrium. An auricular appendage, implanted below the A.V. ring, will thus be lodged in the ventricular cavity, underneath the anterior mitral cusp. Unfortunately, the region is overlain by the coronary vessels, which must be prepared and retracted.

Dissection of the coronary vessels. To make the coronary vessels readily accessible, a longitudinal incision, through the pericardium, parallel to the phrenic nerve which crosses the auricular appendage, is advisable. The auricular appendage is lifted and stretched. A subepicardial procaine (1 per cent) infiltration is started at the base of the appendage and continued to the left above the coronary vessels (Fig. 3). The epicardium is thereby elevated, making possible the infiltration behind the coronary vessels to eliminate disturbing reflexes. By this, the preparation of the coronary vessels is made easier also. The incision of the epicardium is carried out above the coronary vessels, 1½ cm. to the left of the aortic root to avoid the proximal left auricular branch of the circumflex coronary artery, although "there are abundant anastomoses between the left and right auricular arteries" (Moore).¹⁰ The incision is continued to the left for a distance corresponding to the width of the appendage (Fig. 4). An arteriole and venule are tied off at the left margin of the appendage (Fig. 5). Blunt, half-curved scissors spread

FIG. 5

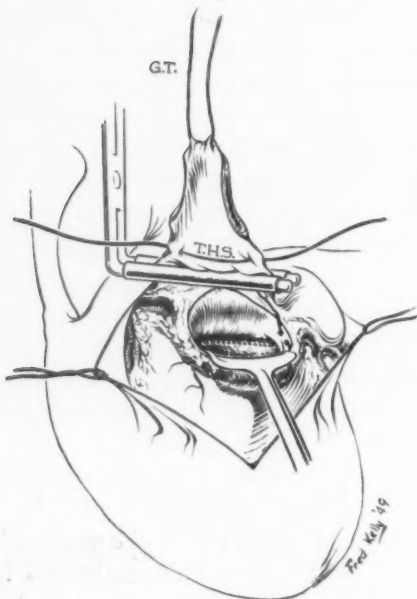


FIG. 6

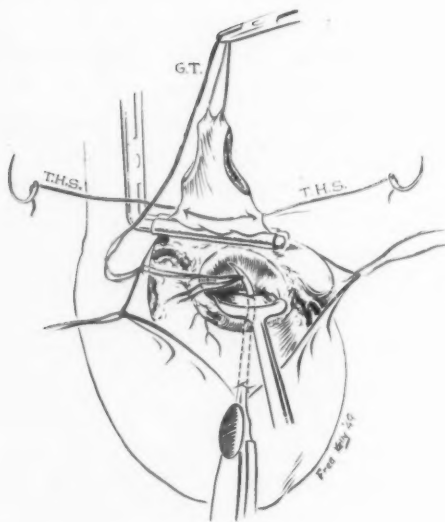


FIG. 7

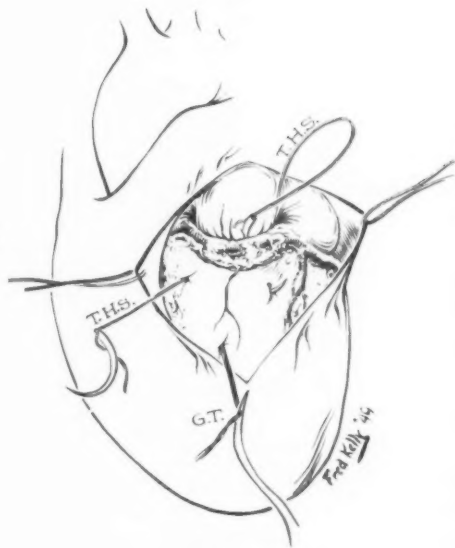


FIG. 8

FIG. 5.—The "step" formed by the atrial wall and the upper end of the myocardium. The auricular appendage is prepared for implantation. (G. T. = Guide thread; T.H.S. = temporary hemostatic suture. The dotted line marks the site of the ventricular incision.)

FIG. 6.—The index finger is in the ventricular cavity, anterior to the mitral cusp and behind the coronary vessels. A Reverdin needle contacts the tip of the finger.

FIG. 7.—The Reverdin needle, appearing through the incision, is threaded with the guide thread. The T.H.S. is ready for use.

FIG. 8.—The auricular appendage has been implanted by withdrawing the Reverdin needle and pulling on the guide thread. The T.H.S. is being placed.

behind and along the coronary vessels are used to separate them from the atrial wall (Fig. 4). The vessels are retracted by a blunt retractor and the dissection is continued more deeply until the upper end of the ventricular myocardium is clearly seen (Fig. 5). The desired anatomical picture is similar to a "step" of a stair, the tread being represented by the upper end of the myocardium, and the rise by the atrial wall. In the angle formed by these two planes is the fibrous A.V. ring, which must be clearly exposed. A small sponge is inserted into this inter-space, stopping any oozing while the appendage is being prepared.

The preparation of the appendage is the same as on the right heart.

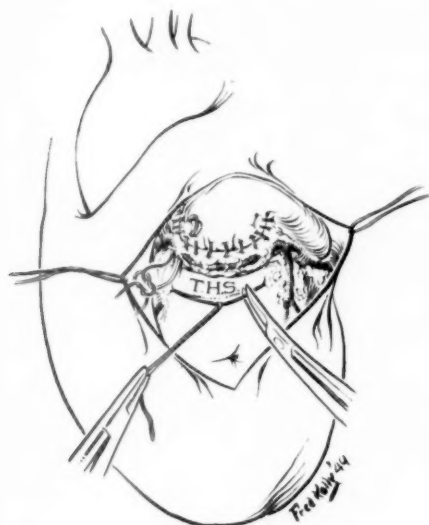


FIG. 9

FIG. 9.—The anterior wall of the implanted appendage is joined by a running suture to the fatty tissue around the coronary vessels. The corners at the base of the appendage are secured by separate mattress sutures. The guide thread is permanently fixed. The T.H.S. is cut before it is withdrawn.

FIG. 10.—Diagram illustrating the valvular mechanism of the anastomosis synchronized with the function of the A. V. valves.

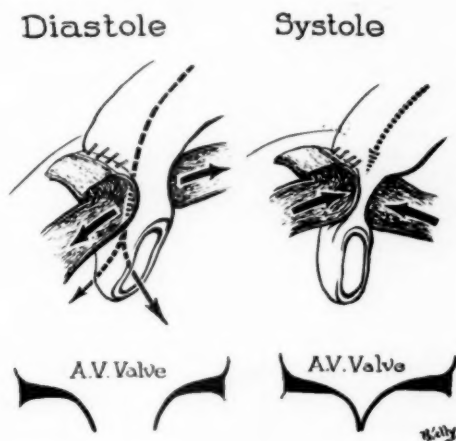


FIG. 10

Opening the left ventricle. After the sponge is removed, the coronary vessels are displaced, using one or two blunt retractors. The "step" is clearly exposed. A pair of half-curved scissors, having the exterior edges sharpened, and the distance of spread fixed by a screw, are used to incise the ventricle. The closed scissors are pushed through the upper end of the myocardium underneath the A.V. ring, the half-curve following the intermediate position of the valve. The scissors are spread and withdrawn, executing the incision by their sharp exterior edges. Blood spurts, but is stopped immediately by introducing the left index finger into the opening (Fig. 6). The papillary muscle can be felt by the tip of the finger with the chordae tendinae behind it. When these landmarks are identified the tip of the finger fixes a point on the anterior wall, below the cusp. A half-curved Reverdin needle is

inserted through the myocardium, making contact at this point with the tip of the finger. As the finger is withdrawn, the Reverdin needle follows in its wake and appears in the incision (Fig. 7). The "guide thread" is threaded into the Reverdin needle, which is then pulled out, quickly drawing the appendage into the ventricular cavity and lodging it with exactitude underneath the chordae tendinae. The temporary hemostatic sutures are placed and tied

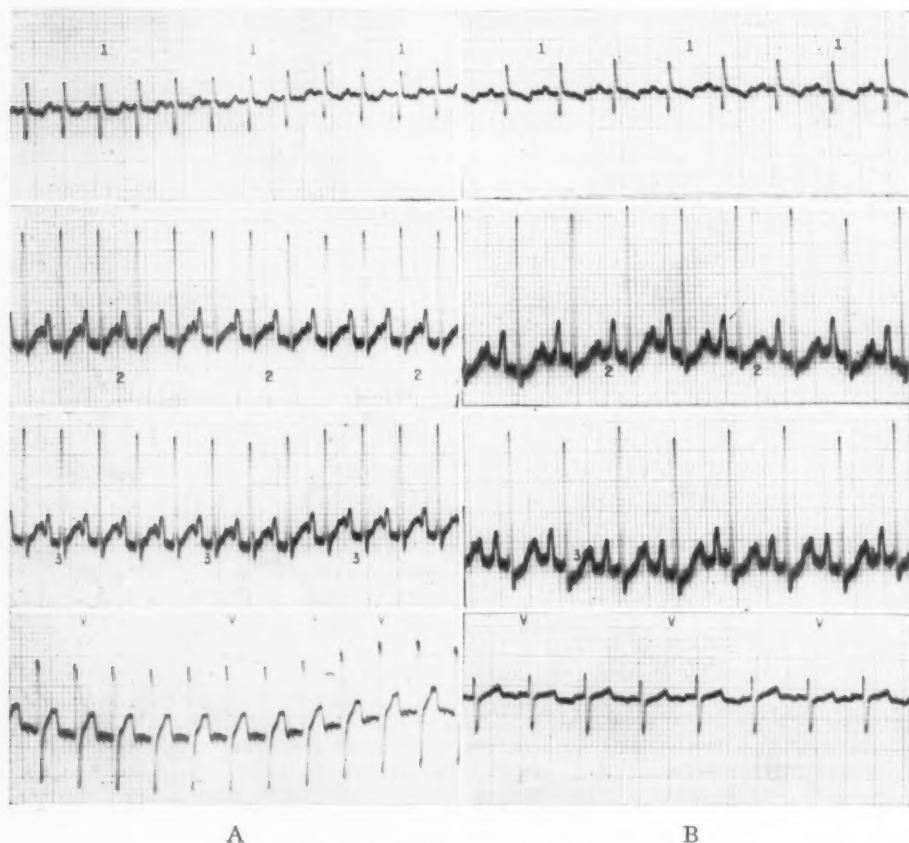


FIG. 11.—Electrocardiogram before (A) and after (B) right atrio-ventricular anastomosis; first, second, third and precordial lead. (Heparin Ser. Dog No. X—February 22, 1949.)

(Fig. 8). Interrupted mattress sutures, joining the auricular wall to the myocardium behind the coronary vessels and starting at the point of maximum hemorrhage, completely arrest all bleeding. If needed, a running suture may be added. Care must be taken to suture the angles at the base of the auricular appendage (Fig. 9). The guide thread itself is used to suture the point at which it emerges and thereby fixes the appendage in a moderately stretched position to the anterior ventricular wall. The T.H.S. is cut and withdrawn (Fig. 9).

The understanding of the valvular mechanism in the anastomosis is facilitated by Figure 10. There are two factors which insure the closing of the anastomosis in systole and its opening in diastole: (1) The ventricular muscle fibres around the implanted appendage close the anastomosis by contraction in systole and open it by relaxation in diastole. (2) The rising intraventricular pressure in the isometric phase of systole brings the anterior and posterior walls of the appendage close together, shutting the blood passage and synchronizing the function of the anastomosis with the action of the atrio-ventricular valves. This was proved in one case by the observation of a bulged posterior wall of the auricular appendage, and in another where the tip of the appendage was not fixed to the anterior wall of the ventricle, by the occurrence of a gliding herniation, even inversion, of the posterior appendicular wall into the left atrium.

RESULTS

The following observations have been made during the operation: No regurgitation through the anastomosis is ever observed. As long as the clamp at the base of the auricular appendage remains closed no ventricular pulsations in the appendage and no hemorrhage are seen. After the clamp is opened, blood from the atrium streams through the anastomosis and pulsates in rhythm with the atrium. Bleeding may now occur around the stitch openings accidentally torn in the thin wall of the appendage. This bleeding can be controlled easily.

The operation is usually very well tolerated. Direct recording of the blood pressure during the entire operation shows only a 10 mm. mercury drop in pressure. Electrocardiograms before and after operation show insignificant changes (Fig. 11).

The operation has been carried out also on old, fat and diseased dogs with success. Nine dogs with previous operation on the arterial heart, after four to six weeks had the operation performed on the venous heart and recovered.

The postoperative course, if not complicated (mostly by intrathoracic hemorrhage following heparin treatment), is uneventful. The dogs regain their normal health and activity after two weeks.

Unfortunately, these operations are followed by thrombosis and complete obstruction of the anastomosis, if not treated by a continuous intravenous flow of heparin (Fig. 12). Infusing dogs with 15 to 20 units of heparin per kilogram per hour for five to six days resulted in patency. Of 24 dogs operated upon (13 right heart, 11 left heart), observed over a period of 14 days, and with heparin infused postoperatively, 13 (54 per cent) were found to have a patent anastomosis (Fig. 13). By the end of 14 days the lesions of the endocardium produced during operation had become covered by a layer of stretched and thinned cells (Fig. 14). These were our first results and are being improved.

In the last series of 13 right atrio-ventricular anastomoses no deaths occurred on the table. In this operation on the left heart, casualties by

hemorrhage from accidental tears are now rare. However, the preparation and retraction of the coronary vessels which must be carried out require precise technic. We lost over 20 dogs before all details of technic for an exact implantation of the auricular appendage underneath the chordae tendinae had been well defined.

TECHNICAL CONSIDERATIONS

Some general and special technical remarks have to be made which are important for this kind of experimental surgery.

Anesthesia. A 5 per cent nembutal solution—0.7 cc. (35 mg.) per Kg.—provides a good anesthesia for hours. If necessary, additional amounts may



FIG. 12.—The ventricular opening of the anastomosis is obstructed by a mural thrombus in a case which was not heparinized postoperatively. A groove enters the auricular opening of the right appendage and breaks through the mural thrombus into the ventricular cavity. (Dog No. 10. Operation June 24, 1948, on the left heart and August 28, 1948, on the right heart.)

be injected, intravenously or into the left ventricle. Injection into the right ventricle sometimes produces a dissociation in rhythm of the two ventricles and even death from acute dilatation.

Artificial Respiration. The tracheal tube used for the artificial respiration should fit snugly to avoid over-ventilation and to ensure positive pressure. The pressure, however, should be moderate in order to facilitate the exposure of the heart and not to increase the burden on the right ventricle. For the same reason, the air from the chest was not expelled by excessive inflation of the lungs during closure, but evacuated by suction from the closed thorax.

The rules of asepsis must be strictly observed, but the injection of one vial of crystalline penicillin (200,000 units) into the chest, before closing it,

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helps to avoid empyema or pericarditis. Only one of all operated dogs showed purulent pericarditis, and this dog had not received penicillin.

Although the heart becomes less sensitive to mechanical stimulation during the operation, cocaine solution (5 per cent) was used to paint the pericardium

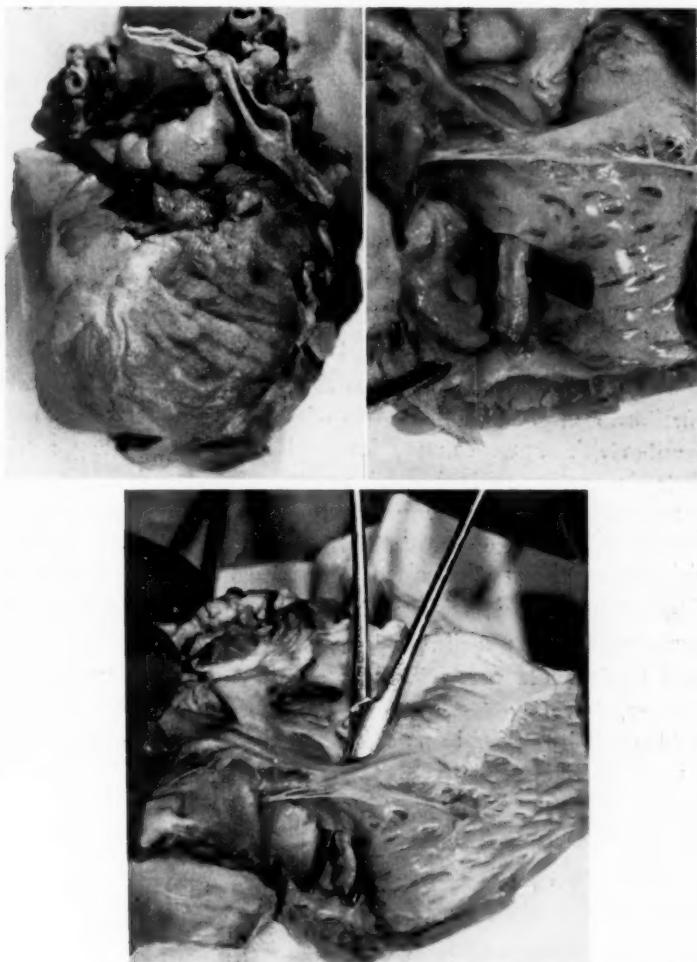


FIG. 13.—Exterior and interior aspect of a right atrio-ventricular anastomosis 14 days after operation. The black arrow marks the site of implantation. The patent anastomosis admits the spread of a curved hemostat. The upper right shows a piece of black rubber tubing inserted through the lateral openings of the implanted appendage, demonstrating the posterior flap. (Heparin Ser. Dog No. X—February 22, 1949).

and epicardium in order to eliminate disturbing reflexes at the start of the manipulations.

"Disturbances provoked by the mechanical stimulus of an instrument touching the left auricular appendage . . ." (Wilson)¹¹ could not be confirmed.

After painting and slightly rubbing the auricular appendage with a tampon soaked in cocaine solution, grasping and stretching of the appendage did not change the rhythm of the heart activity. Local anesthesia by infiltration with novocaine solution (1 per cent) subepicardially and around the left circumflex coronary vessels, made the preparation of these vessels safe and much easier. Slight changes in heart activity occurred as a result of excessive pull with the retractor on the coronary vessels. This traction rotates the heart around an axis passing through the pedicle, which may become kinked. Upon relaxation of this rotation the irregularities cease.

All these mechanical stimuli produce less disturbance than is caused by touching the endocardium. Each penetrating stitch produces a slight ventricular flutter. The ventricular incision, whereby an instrument piercing the endocardium is introduced into the ventricular cavity, causes, of course, similar transitory irregularities. But no stoppage was observed while incising the ventricle.

In enumerating the complications of this operation, three main ones should be mentioned:

1. Immediate and delayed hemorrhage.
2. Thrombosis.
3. Scarring.

The danger of hemorrhage when opening the ventricle is considerably diminished by using the special scissors, which reduce to a matter of seconds the time elapsing between incision and implantation of the appendage. Abundant hemorrhage is produced in the left atrio-ventricular anastomosis mainly by accidental tears while preparing the coronary vessels. The pull on the lifted appendage, therefore, has to be gentle. On the other hand, a tear in the thin myo-endocardium, behind the coronary vessels, can hardly be sutured. The auricular appendage lined by mesothelium is an ideal padding material. We were able to save several dogs by oversewing the tear with a pad of this tissue. The dogs, although not infused postoperatively with heparin, showed at the site of damage perfect healing without any sign of a mural thrombus.

As is evident from our technic, the operation is carried out on the freely beating heart, and no attempt is made to operate in a bloodless field. However, the hemorrhage during the operation can be diminished by exact teamwork. An assistant, damming the hemorrhage by digital pressure, lifting his finger only for the placing of sutures, is of great help.

The delayed hemorrhage can be avoided by a careful scrutinizing of the area of implantation. Special attention must be given to the corners at the base of the appendage which also have to be sutured with exactitude. An inspection of the posterior surface of the heart should be made to ascertain that there is no blood escaping that way into the pericardial cavity. Any oozing can be controlled by a spray of topical thrombin. Eventual drainage of blood or effusion from the pericardial sac into the pleural cavity is guar-

anted by stitching the edges of the pericardium with interrupted sutures at intervals of 2 cm. This will prevent cardiac tamponade.

The danger of mural *thrombosis* is always present. This was observed in acute experiments, examining the heart immediately after death. The injury to the endo-myocardium when incising the ventricle is followed by an abundant release of thrombokinase. The inner opening of the ventricular incision was always found to be plastered by a mass of fibrin threads. Thus the usual rules of avoiding thrombosis should be respected. We recommend clean-cut surfaces, a minimum of trauma to the auricular appendage which is clamped at its base by a very weak-jawed rubber-shod clamp, a minimum of foreign material, especially penetrating stitches, and also an intraventricular injection of heparin before implantation. Solandt, Nassim and Best¹² have shown that mural thrombosis can be prevented by continuous heparinization. Indeed, this intracardiac surgery is done in vain if not followed by continuous intensive heparin treatment.

Ligation of coronary branches is to be avoided as much as possible, for a myocardial infarct will increase thrombosis and scarring.

The danger of *scarring* is greater in heart muscle than in blood vessels. However, scarring can be diminished by damaging the myocardial fibres as little as possible by ischemia, and by minimizing the number of stitches, especially the constricting stitches. The technic described above differs from that indicated in an earlier publication (Rappaport, Murray and Davies¹³) by leaving out as far as possible any mattress sutures which render ischemic the muscle fibres, leading to necrosis, myocardial scar and even calcification (Fig. 15).^{*} These sutures are replaced by a running suture in the right A.V. anastomosis which joins the auricular epicardium to the ventricular endocardium, producing a fine linear scar. The posterior row of sutures on the other hand is no longer used, thus diminishing the amount of foreign material in the myocardium and avoiding a circular suture and scarring of the anastomosis. There is no hemorrhage if the margins of the appendage are sutured, closing the space behind the appendage. No hematoma, which could narrow the created opening, has been observed in this space.

DISCUSSION

It would seem from the foregoing that this is tedious work, accompanied by serious risk for what appears to be a small artificial communication between the heart chambers. However, considering the work of Dimitrieff,⁵ Souttar,⁹ Cutler and Beck,⁸ Wilson¹¹ and others, who, using the auricular appendage as a way of approach, introduced one finger or a valvulotome into the heart cavity, and recalling that slightly more than one finger can pass through the valvular ring of the aorta, it is possible to estimate, roughly, the amount of blood that could flow through the anastomosis and increase the blood supply of the systemic circulation. Although, in operated dogs, no

^{*} We are indebted to Dr. W. Stanley Hartroft for his explanatory histological findings. These were the starting point for an important change in technic.

obstacle was encountered by the blood in streaming through the normal A.V. valves, the created patent by-pass admitted the spread of a curved hemostat.

Considering the other surgical methods for relieving valvular stenosis, we must cite the fine experimental work of W. C. Wilson¹¹ and two of his conclusions:

1. "Surgical treatment (partial valvectomy) of mitral stenosis involves converting the condition of stenosis into incompetence of the valve."

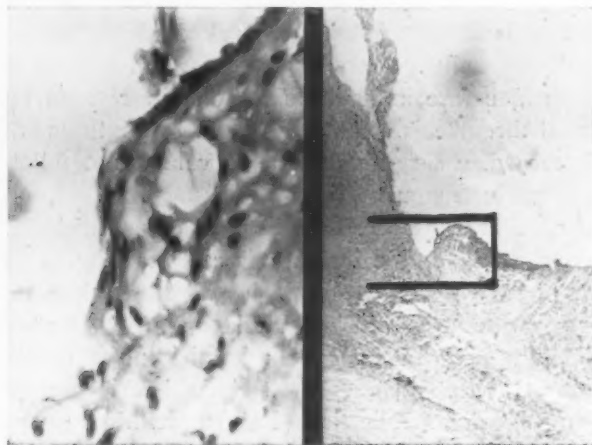


FIG. 14.—D99-43. H & E stain. On the right is a low power view of the passage made at operation. The enclosed area is magnified on the left to show a layer of two or three stretched and thinned cells, covering the underlying scar tissue. Magnifications are $\times 35$ and $\times 500$. (Dr. W. Stanley Hartroft)

2. "There is as yet no proof that the heart in which the mitral valve is stenosed can readily tolerate a sudden change to incompetence, nor that such a change will be beneficial."

It has also been shown that even a healthy animal will succumb if a severe grade of mitral incompetence be produced. We confirmed this finding by accidentally cutting the chordae tendinae of the anterior cusp. The dog had a loud systolic murmur, showed clinical signs of mitral insufficiency, and died. Holman and Beck¹⁴ report a similar case. "Valvuloplasty" (Harken¹⁵) is an attempt to reduce this danger by creating a "selected insufficiency" of the mitral valve. Another effective procedure to enlarge the stenotic valve is "mitral commissurotomy" (Bailey¹⁶), provided that the separated leaflets do not unite again as observed by Evarts Graham.

The interauricular communication suggested by Jarotzky³ and tried experimentally by Schepelmann,¹ Dimitrieff⁵ and others, increases the burden on the right ventricle, already working at the limit of its capacity because of the mitral stenosis. Treatment by dilation of the stenosed valve, as executed by

Souttar⁹ and Pribram,¹⁷ does not eliminate the danger of the sudden change to valvular incompetence and does not prevent the recurrence of the constriction. As pointed out by W. C. Wilson:¹¹ "Treatment by dilatation of pathological stricture in other parts of the body must be intermittent and repeated . . . instrumental dilatation of the mitral valve does not appear as yet to be feasible."

The atrio-ventricular anastomosis tends to restore, in a graduated manner, the blood supply for the systemic circulation, adding a new passage with valvular action to the stenosed A.V. openings. In this valvular anastomosis the flow will be regulated by the difference of pressure between atrium and

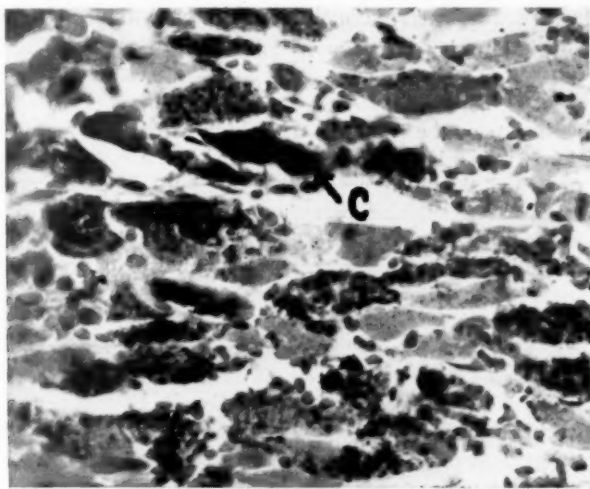


FIG. 15.—"The dark masses (C) are calcium salt deposition in damaged muscle cells." (Dr. W. Stanley Hartroft) (Dog A. C. 6—July 12, 1948) H. & E. Stain x 270.

ventricle. The more the ventricular capacity is increased by better filling (Beck and Holman¹⁴), the greater will be the decongestion of the dilated atrium and congested lungs. We agree with Hellerstein, Sinaiko and Dolgin¹⁸ that in the stage of auricular dilatation the auricular appendage is a dangerous container of thrombi, but we must state that an opened and implanted appendage ceases to be a blunt cavity. As an open channel, blood streams through it under the same conditions as in the other cavities of the heart.

SUMMARY

1. A method of creating an anastomosis between an atrium and its corresponding ventricle by implantation of the opened auricular appendage into the ventricular cavity has been investigated experimentally.
2. A special technic for implantation of the left auricular appendage behind the coronary vessels has been elaborated.

3. The atrio-ventricular anastomosis, allowing the blood to flow only in one direction from the atrium to the ventricle, has valvular properties.
4. The attempt to obtain a valvular action is justified by the need for maintaining the physiologic direction of the blood flow in the heart chambers. Other methods might increase the burden on the heart.
5. The atrio-ventricular anastomosis is a method intended to relieve the congestion and to return the blood to the ventricle where it is required.
6. The injuries inflicted upon the endo- and myocardium by the surgical procedure of establishing an A.V. anastomosis are followed regularly by mural thrombosis around and in the appendage. The thrombus obstructs the anastomosis.
7. Therefore, postoperative continuous intravenous infusion of heparin was found to be absolutely necessary.

In recent experiments on the left heart a slight modification of technic has simplified the procedure and has reduced the loss of blood during the operation. In this modification, a specially designed thumb forceps is employed to displace the coronary vessels without pinching them. The suturing procedure was thereby simplified, eliminating the "temporary hemostatic suture."

Further details will be given in a future publication.

It is a pleasure for us to express our gratitude to Dr. C. H. Best for providing the facilities for this work and for his continuous interest and encouragement. We are thankful also to Dr. J. Markowitz for his kindness; these experiments were carried out in his section of the Department.

Many thanks to the ever friendly and helpful Dr. R. E. Haist, and also to Dr. G. Robinson for his regular and fine assistance. We are grateful to Miss Maria T. Wishart, Director of the Department of Art as Applied to Medicine, and to Mr. Fred Kelly, to whom credit for all drawings is due. The technical help given by Mr. F. Robinson, Mr. H. Smith and Mr. J. Royce is greatly appreciated.

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TECHNIC OF RESECTION OF COARCTATION OF THE AORTA WITH AID OF NEW INSTRUMENTS*

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Well-founded fear of sudden uncontrollable hemorrhage disturbs every surgeon who has resected a coarctation of the aorta. To lessen this worry, new coarctation clamps, and a vise to hold them, have been devised. These instruments have been tested in experimental studies on many dogs. The clamps have proved satisfactory in resection of five coarctations of the aorta.

This clamp† (Fig. 1) utilizes the same principle as the ductus clamp previously described.¹ In the apposing jaws are many fine teeth—40 to an inch (16 to 1 cm.). The serrated portion of the clamp is 1.25 inches (3.2 cm.) long. The jaws and the hub of the clamp are so constructed that the teeth can appose but interdigitate only very slightly at the ends. When the clamp is closed on the aorta the spring of the jaws comes into effect and pressure of the teeth on the walls is evenly distributed. The tiny teeth embed themselves superficially in the tissue and will not slip. Neither will they injure the vessel. A certain amount of judgment must be exercised in closing these clamps on the aorta. If the vessel wall is very thick, complete and safe occlusion will be accomplished by closing the clamps to the second instead of the third notch. If, in experimental surgery on dogs, it is found that the intima has been broken, the clamp has been closed too tightly.

Further worries to the surgeon include the hazard that the assistant holding the clamps may inadvertently unlock one, or he may become excessively fatigued and allow the clamps to slip from his hands while the anastomosis is being done. To overcome these hazards, a vise (Fig. 2) has been fashioned which fits on the coarctation clamps, holding each firmly and allowing proper adjustment for unhurried suture (Fig. 3).

OPERATION

Dr. William O. McQuiston has given the anesthesia for all of these patients. As the anesthesia is begun, a large needle is fixed in the right saphenous vein at the ankle for the administration of fluids and blood. For this operation, 1000 cc. of blood is routinely available in the operating room. The anesthetized patient is intubated and turned on his right side.

A long curved posterolateral incision (Fig. 4A) is made beneath the left scapula, and the chest is entered through the base of the resected fifth rib. Much bleeding of the chest wall is encountered.

* Submitted for publication August, 1949. Report of this work has been delayed because sufficient dogs were not promptly available for experimental purposes.

† Instruments made by Bruno Richter, 843 Duane Avenue, Glen Ellyn, Illinois.

RESECTION OF COARCTATION OF AORTA

The parietal pleura over the constricted portion of the aorta is cut longitudinally. Carefully avoiding injury to intercostal vessels, the aorta is freed sufficiently above and below the constriction. Strips of umbilical tape are passed beneath the aorta; they serve as tractors to elevate the aorta and are safeguards for the control of unexpected sudden hemorrhage (Fig. 4B). The

FIG. 1

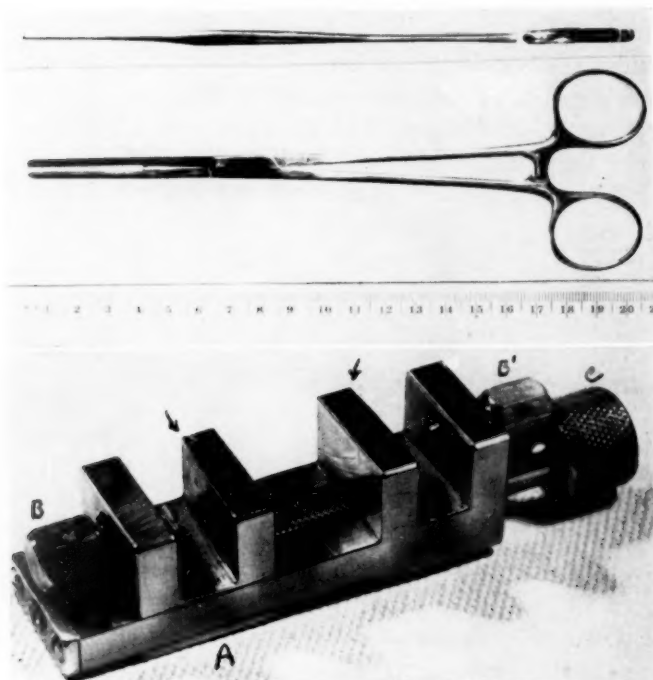


FIG. 2

FIG. 1.—Two views of coarctation clamp with multiple fine teeth in apposing jaws.

FIG. 2.—Vise for holding coarctation clamps. The clamps are held fast (see Fig. 3) by tightening the nuts B and B'. Turning knurled nut C slides mechanism A to the desired position. The surfaces of the U-shaped clamp holding mechanism (indicated by arrows) are ground down slightly so that the grasping ends of the clamps are parallel.

ductus arteriosus or the ligamentum arteriosus is next dissected from its bed. If open, it is properly ligated and cut; if closed, it is still properly ligated and cut as an added precaution.

Painstaking and wide dissection of the aorta above and below the coarctation is essential. Intercostal arteries are thin and easily torn. Only those intercostal arteries, usually one or two, which arise at or near the coarctation and which will be in the way during suture, are doubly ligated and cut.

The clamps are now applied (Fig. 4C) above and below the segment to be resected. It is needless to say that they must be placed far enough away from the lines of section to allow plenty of room for sewing. The constricted segment is cut out with a sharp scissors at such levels that the open ends of the aorta are of practically similar diameter. All blood is lavaged away with a stream of physiologic saline solution.

The vise is now applied, (Fig. 4D) being sure that the clamps are snugly fixed. By turning the knurled nut, the segments of the aorta are drawn together to exactly the coaptation desired.

The clamps, easily held in one hand by the assistant, are turned forward, and suture is begun at the angle closest to the operator. No. 00000 Deknatel silk has been used in all cases. The over-and-over stitch is carried to the inferior angle, the clamps are turned backward, and the suture is completed (Fig. 4E). The suture is tied to the free end at the point of starting (see discussion).

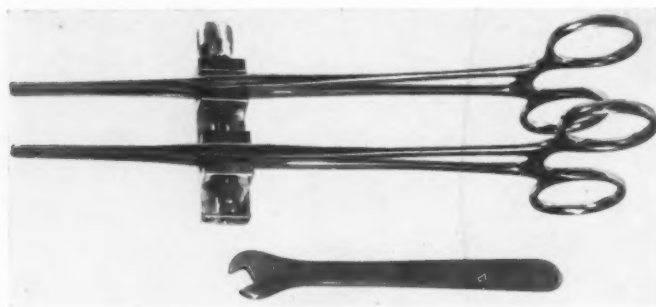


FIG. 3.—The clamps are fixed in the vise with the wrench.

The distal clamp is released first. If there is no bleeding the clamp is removed and the proximal clamp is likewise released and removed. There has been no appreciable drop in blood pressure in any case upon release of the clamps. This is easily explained by the fact that the coarctation clamps are very thin and do not encroach upon the flow of blood through the large branches of the aorta and their extensive communications with the general circulation.

The parietal pleura is closed over the aorta. A mushroom catheter with all but the flange removed is drawn through the sixth or seventh interspace from the inside out. This drainage catheter is later connected with a tube in an under water seal bottle. The bottle is fixed to the floor with adhesive tape and marked so that any drainage from the chest can be detected at a glance. The lung is re-expanded and the chest is closed in layers with fine running catgut sutures. While the anesthetist is making pressure on the anesthetic bag to force all the air out of the chest the drainage catheter is clamped.

Crystalline penicillin in 100,000 unit doses is given twice daily for a week.

RESECTION OF COARCTATION OF AORTA

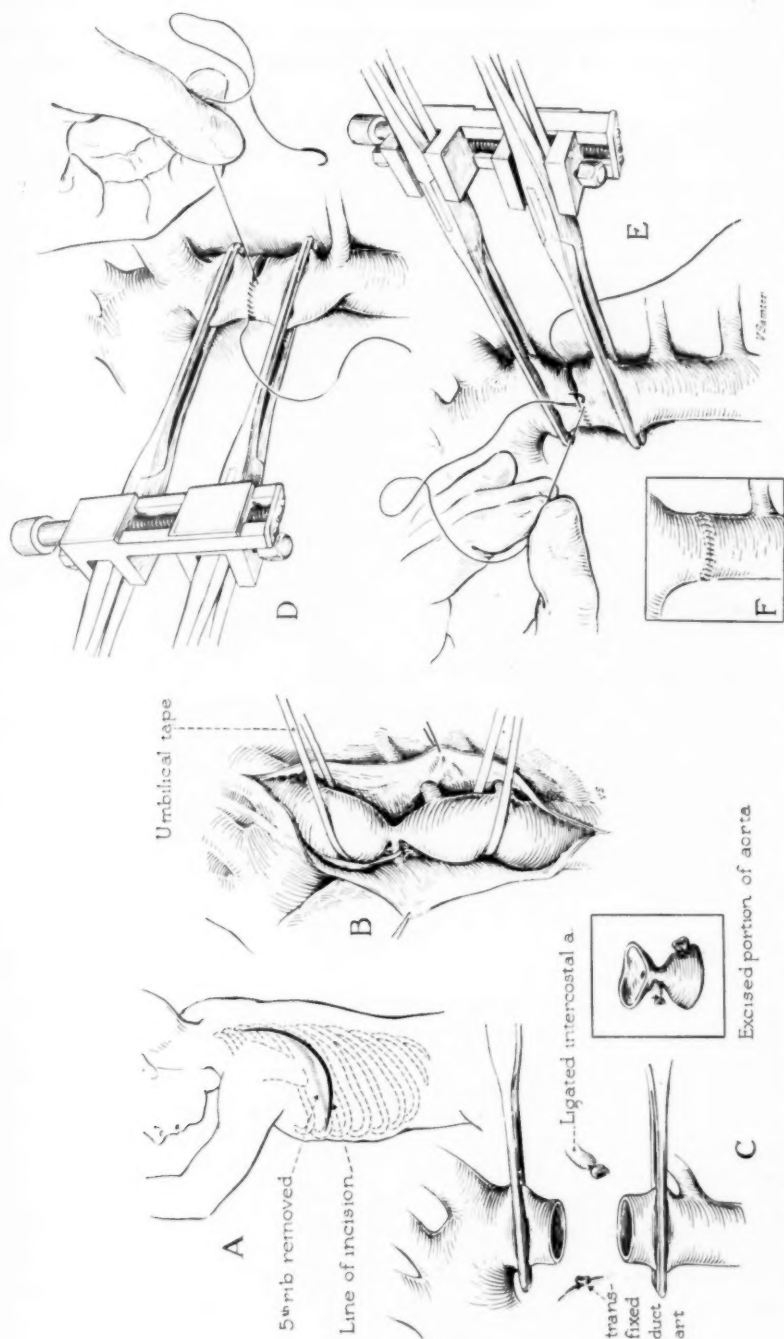


FIG. 4.—(A) The skin incision is well below the tip of the scapula. (B) Umbilical tapes above and below the coarctation are helpful in the dissection. (C) In four out of five cases the ductus arteriosus was attached to the coarcted portion of the aorta. (D) The clamps are turned up and away from the operator, who stands at the patient's back. Suture is begun at the upper angle. (E) The clamps are turned back to their original position and the suture is completed, as indicated in (F).

The patient is kept in the hospital two weeks. Arm and leg blood pressures are measured and recorded every other day.

In each patient the femoral pulse has been vigorous immediately after operation and has remained so. The ages of these five patients were 16, 12, 7, 12 and 11 years.

The record of one patient presenting a difficult operative problem is presented:

L. S., age 16 years, was admitted to The Children's Memorial Hospital, May 17, 1948, with complaints of headache, shortness of breath, fatigue and dizziness of about

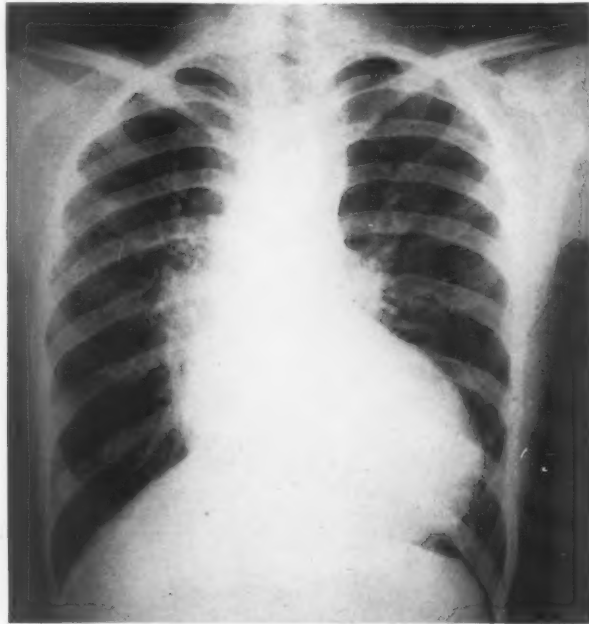


FIG. 5.—The seventh rib on the left side shows characteristic notching. The heart is considerably enlarged.

one year's duration. On physical examination heaving pulsations of the heart were visible and palpable. The carotid arteries pulsated visibly with each heart beat. Pulsations of collateral vessels were palpable in the posterior axillary line on both sides of the chest. Auscultation of the heart revealed a continuous pulsus bigeminus. The blood pressure in the arms was 250/118; in the legs 100/60. A very weak beat was palpable over the femoral arteries. Roentgenologic examination of the chest revealed notching of the ribs and considerable enlargement of the heart, especially of the left ventricle (Fig. 5).

Operation May 19, 1948. The findings at operation were as illustrated in Fig. 6. The aorta merged into the subclavian artery, forming a U, at the bottom of which was the coarctation. The clamps were applied as illustrated and the coarctation was resected. Actually, a segment had to be cut out of the inferior wall of the aorta. An end-to-side anastomosis was done, using an everting mattress suture.

The postoperative course was uneventful. A brisk femoral pulse was immediately palpable after operation. The systolic blood pressure in the arms dropped from 250 to 152 and in the legs rose from 100 to 160.

RESECTION OF COARCTATION OF AORTA

Six months after operation the patient had gained 20 pounds. All of his symptoms were relieved. The blood pressure in the arms was 145/82 and in the legs 160/90. Roentgenologic examination revealed that his heart was definitely smaller than before operation.

DISCUSSION

It has not been finally decided whether the ends of the aorta should be drawn together by an everting intima-to-intima mattress suture or by a simple continuous end-to-end suture. Gross² believes that an everting suture is preferable. Blalock³ believes it is a matter of personal choice whether one

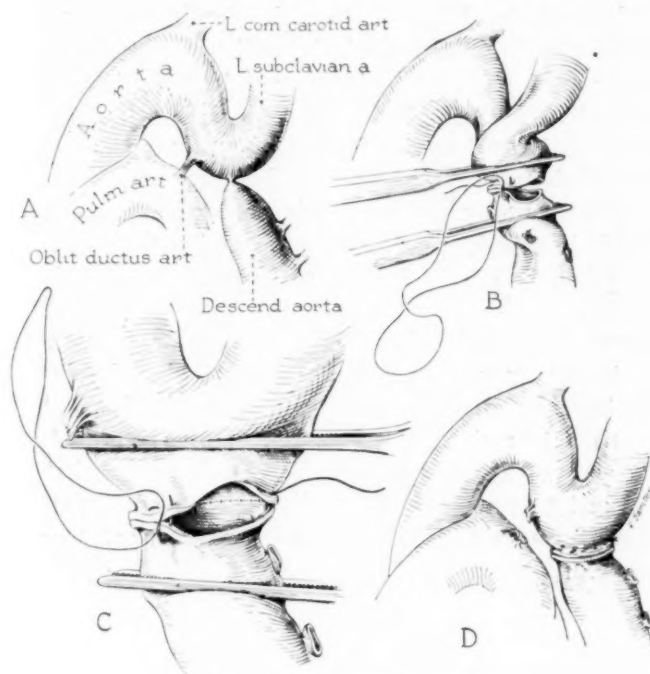


FIG. 5.—See case report in text.

employs an everting or an over-and-over suture in performing the anastomosis. He, however, uses the everting suture. Shumacker⁴ concluded that stricture, dehiscence and the formation of small aneurysms at the site of suture were much less common when everting mattress sutures had been used. He found significant difference in the incidence of thrombosis with the two methods. Crafoord,⁵ on the contrary, prefers anatomic suture with coaptation of the different layers of the aortic wall, because this suture allows resection of a few more millimeters of the obstruction. Jones⁶ uses four interrupted stay sutures combined with running over-and-over sutures. From experimental work to be published by Smith, Riker and Johnson, it appears that an end-to-end suture may be preferable. They have found less tendency

towards immediate leakage from the suture line following end-to-end coaptation. Less tissue is constricted by a continuous suture than by an everting suture. Furthermore, there is less encroachment upon the lumen following end-to-end suture than following an everting suture. In the four patients in whom end-to-end suture was done no bleeding occurred upon release of the clamps. One extra stitch was required in the patient upon whom an everting stitch was used. The question of which method of suture is preferable will be answered after many patients have been studied for many years.

In animals and patients, only a single, continuous 00000 Deknatel suture on an atraumatic, curved needle has been employed. It is rather important for the assistant who holds the thread to maintain exactly the proper tension to coapt the edges snugly. If held too loosely bleeding will occur, if held too tightly the stitches tend to cut through the wall of the vessel.

Should interrupted silk or running catgut be used in these patients to close the chest wall? Actually little difference in the healing is observable except for occasional small accumulations of serum about catgut knots. I doubt whether slightly smoother healing following silk or cotton closure justifies the extra operating and anesthetic time such closure requires. The operation itself is long and trying to operator and patient alike, and salvage of 20 minutes might be crucial for the patient and is valuable for the surgeon's feet.

Coarctation of the aorta is being diagnosed more frequently as the medical profession has become more conscious of the possibility of its existence. The seven-year-old boy in this series was admitted to the hospital with typical acute appendicitis. The resident physician found an unsuspected systolic blood pressure in the arms of 200 mm. of mercury. Having congenital heart disease in mind, he slipped a finger over the groin and found no femoral pulsations. Later studies confirmed a classical coarctation of the aorta, which was successfully resected.

CONCLUSIONS

The technic of resection of coarctation of the aorta by means of new instruments is described.

Five patients have been operated upon with no operative or postoperative complications. There has been no mortality.

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CARCINOMA OF THE THYROID GLAND*

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MALIGNANT TUMORS of the thyroid gland comprise about one per cent of all human cancer; but, because of a multiplicity of characteristics and unlimited predictability, they form a very interesting group of tumors. Benign hyperplasias and hypertrophies, associated with or without hyperthyroidism, are frequently encountered. The relationship of the common encapsulated adenoma and thyroid malignancy is now appreciated, as the former may have all the appearance of a benign tumor but, during an apparent benign course, develop local and distant metastases by the blood stream and lymphatics.

In a series of 112 carcinomas of the thyroid gland carefully studied at the Johns Hopkins Hospital, it was noted that the disease may occur at any age (Table I). There were three cases under ten years of age and 22 under 30. It is one of the more frequent cancers of the neck in children. There were 74 females and 38 males, which is a ratio of about 2 to 1, which can be contrasted with the ratio 6 to 1 that is usually encountered in patients with goiter. Both the white and colored races are involved. There were 82 white and 30 negro patients.

Incidence and etiologic factors. Following Allen Graham's monumental work in 1924,¹⁰ substantial progress has been made in the early diagnosis and treatment of thyroid malignancy. Graham demonstrated the significance of blood vessel invasion as a criterion of thyroid malignancy, stressed the relationship of the discrete adenomata to thyroid cancer, and showed that distant metastases may develop by blood stream invasion from the clinically benign adenoma. Prior to Graham's work, a large percentage of thyroid malignancy was diagnosed in the late stage of the disease, as pathologists had difficulty in making an early correct diagnosis in a substantial percentage. The late stage of the disease is manifested by large fixed glands which have infiltrated the adjacent structures, associated with pain, hoarseness, obstruction of the trachea, and, at times, the esophagus.

It is asserted that 80 per cent of thyroid cancers have origin in fetal adenoma. Numerous investigators have discussed the relationship of the development of cancer in adenomatous goiter and the discrete adenomata. Students of thyroid disease are now cognizant of the relationship of adenomatous goiter and discrete adenoma to thyroid cancer, but many physicians do

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not appreciate its importance. It is conservatively estimated that from 4 to 20 per cent of discrete adenoma develop into cancer, irrespective of age. However, the younger the patient, the greater the danger of malignant transformation. It is necessary that discrete adenomata be removed before silent or frank cancers develop. Thyroid cancers may be present for months, due to their low histologic grade, before clinical manifestations are present. Such cancers invariably have origin in adenomatous goiter or discrete adenoma.

TABLE I.—*Ages of 112 Carcinomas of the Thyroid.*

1-10 years of age.....	3 (youngest 4 years of age)
11-20 years of age.....	2
21-30 years of age.....	17
31-40 years of age.....	20
41-50 years of age.....	22
51-60 years of age.....	26
61-70 years of age.....	20
71-80 years of age.....	2 (oldest 80 years of age)

The relationship between a pre-existing thyroid abnormality and development of thyroid cancer, as noted in this series of cases, is shown in Table II. Eighty-seven (or 77 per cent) of these patients gave a history of thyroid abnormality existing prior to the symptoms of cancer. Twenty patients had an aberrant position of the apparent initial tumor which is indicative that the corresponding lobe of the thyroid was involved by a low-grade cancer. It is our opinion that aberrant papillary malignant tissue represents metastases from the lobe of the involved side.

Various investigators during the past few years have stressed the relationship of carcinoma of the thyroid to hyperthyroidism (exophthalmic goiter) and hyperfunctioning adenomatous goiter. Early, Rienhoff and Lewis²⁴ demonstrated that 8 per cent of the hyperplastic glands studied in their laboratory contained fetal adenomata. Pemberton,³⁰⁻³² reporting from the Mayo Clinic, using the basal metabolic rate as a criterion of hyperthyroidism,

TABLE II

1. Discrete adenomata in a normal position.....	23
2. Aberrant position.....	20
3. Multiple adenomata.....	16
4. Bilateral adenomata.....	5
5. Diffuse involvement of the entire thyroid....	23
6. One lobe diffusely involved.....	10

found 33.5 per cent of a group of thyroid cancers had a basal metabolic rate above normal. Black,³ reporting from the same clinic, stated that 16 per cent of the cases of thyroid cancers studied by him were associated with exophthalmic goiter. Our criteria of symptoms of hyperthyroidism are excessive appetite, nervousness, tachycardia, sensitivity to heat, and weight loss. In the group of cases herein reported from the Johns Hopkins Hospital, these symp-

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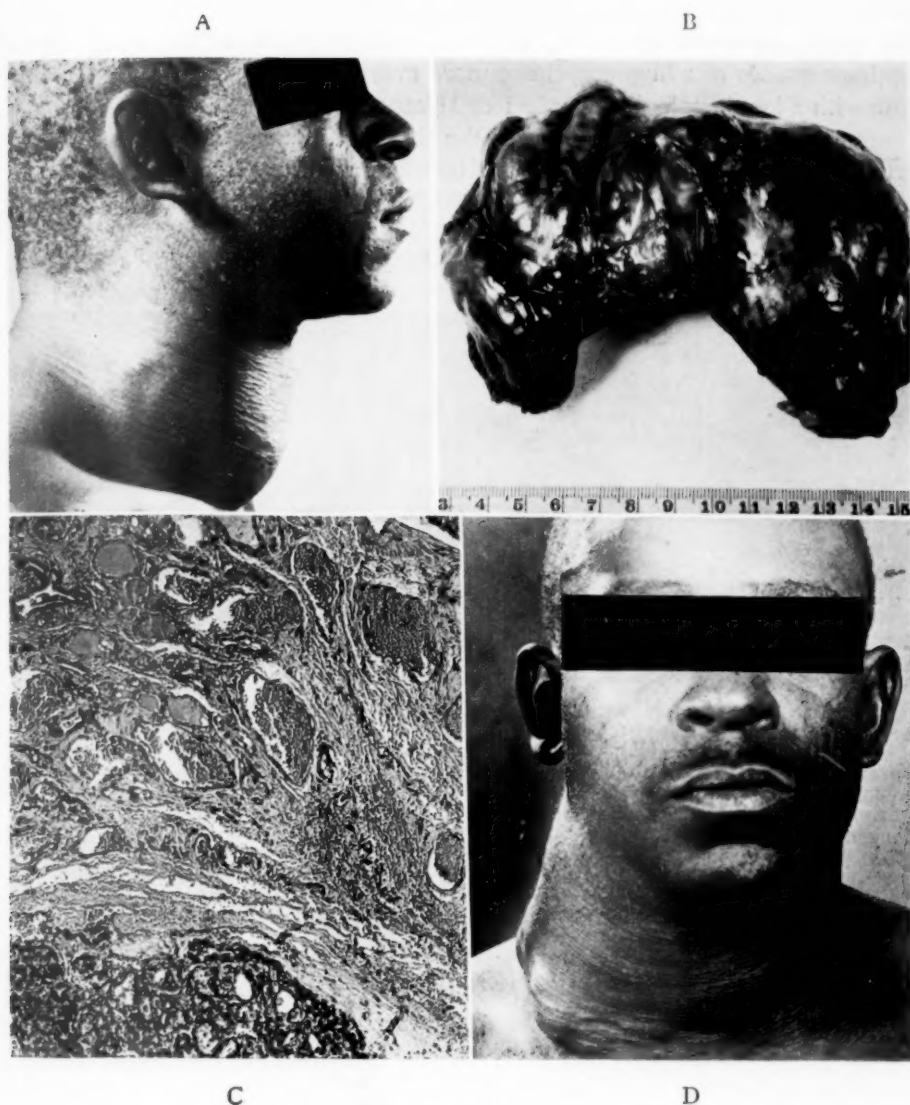


FIG. 1.—Carcinoma and diffuse toxic goiter. (A) Colored male, 36 years of age. History of diffuse enlargement of thyroid with symptoms of hyperthyroidism of two years' duration; BMR +35. The gland was diffusely enlarged with no clinical evidence of malignancy present. (B) Specimen removed, showing enlargement of both lobes and isthmus. (C) Photomicrograph showing poorly formed acini, with watery type of colloid. Cells lined with low cuboidal epithelium. Infiltration with strands of epithelial cells, with dark-staining nuclei. Invasion of blood vessels. (D) Recurrence in right lobe. Tumor is hard and nodular, producing tracheal deviation; no evidence of involvement of right recurrent laryngeal nerve.

toms were present in 30, or 26 per cent. Only 24, or 21 per cent, of the patients with symptoms of hyperthyroidism also had an elevated basal metabolic rate (i.e., above $+15$). It is well established that patients with high histologic grades of malignancy have more evidence of hyperthyroidism than those with a low histological Grade I or II cancer (Fig. 4). This is confirmed in our group of cases. Carcinoma of the thyroid frequently only involves a part or all of one lobe, and should not be a contributing factor in producing an elevation of the basal metabolic rate. Therefore, association of hyperthyroidism (using the basal metabolic rate as a criterion) and cancer is not clear.

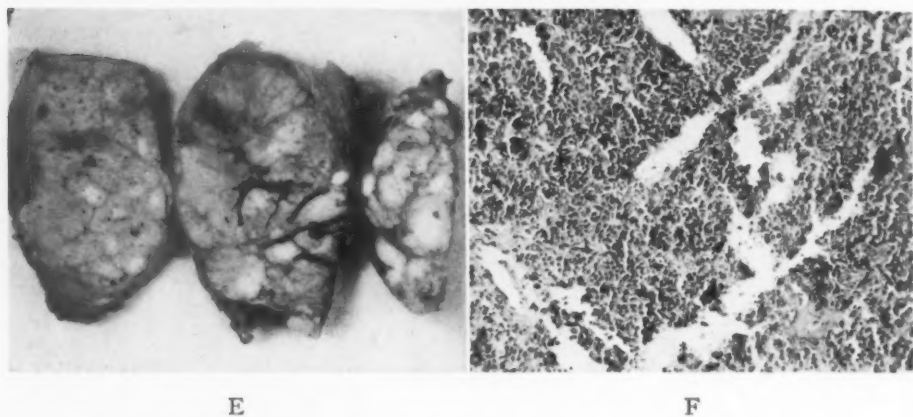


FIG. 1. (Cont'd.)—(E) Cross-section of the tumor showing lobulations. One area shows degeneration. (F) Photomicrograph showing undifferentiated carcinoma; infiltration with strands and nests of epithelial cells, some attempting acini formation. Cells contain hyperchromatic nuclei. Connective tissue is poorly staining and sparse.

CLASSIFICATION OF MALIGNANT TUMORS OF THE THYROID GLAND

Benign and malignant tumors of the thyroid gland produce a notable variation in their histopathology. Because of its protean nature, there is not always a definite relationship between the clinical course and the pathology of the thyroid malignancy. However, the clinico-pathologic classification suggested by Shields Warren³⁹ and adopted from Allen Graham¹⁰ is a practical one. This classification is now used by the American Goiter Association and is widely accepted. The number of our cases falling into each group are charted.

Group I.—Malignant Adenomata (adenomas with blood vessel invasion and papillary cystadenomas). The etiology of this type of malignancy, as its name suggests, is in benign embryonal or fetal adenomas that occur discretely or as multiple adenomata. Most of these tumors are of low histologic grade, either I or II. Graham¹⁰ noted the frequency of blood vessel invasion and considered this phenomenon the criterion of malignancy. Distant metastases to the lungs or osseous system may occur with little change having taken

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place in the clinical picture of the parent tumor. Metastases by the lymphatic vessels does not occur, as a rule, until the growth has infiltrated and invaded its capsule.

Twenty patients had undergone previous thyroid operations before consulting our clinics. There was a local recurrence in 11, and nine had been advised that cancer was present and further surgical therapy or irradiation was necessary. Even though it is not always possible to determine whether a previous operation was for a benign or malignant condition, the patients that were re-operated upon were found to have a malignancy tumor.

So-called *lateral aberrant thyroid tissue tumors* have been the subject of controversy among students of thyroid disease for many years. Lowe, in 1903,¹⁰ demonstrated that tissue found in the lateral surface of the neck was similar histologically to tumors present in the thyroid gland. It was thought until recently that the associated papillomatous change of a malignant nature

TABLE III

1. Low grade malignancy	
a. Adenoma with blood vessel invasion.....	36
b. Papillary cystadenoma.....	25
(a and b are frequently grouped together)	61
2. Moderate grade of malignancy	
a. Papillary adenocarcinoma.....	20
b. Alveolar adenocarcinoma.....	11
c. Hurthle cell carcinoma.....	6
3. High grade malignancy	
a. Small cell or carcinoma simplex.....	5
(compact and diffuse type)	
b. Giant cell carcinoma.....	1
c. Epidermoid carcinoma.....	3
d. Fibrosarcoma.....	4
e. Angiosarcoma.....	1

found in the corresponding lobe of the thyroid was extension to the thyroid from the malignancy in the lateral cervical aberrant tissue. There occasionally develops in one or both sides of the neck a papillomatous glandular structure from the ultimobranchial body, which has been designated as lateral aberrant thyroid tissue. When present, the gland masses vary in size and consistency, and usually are found along the anterior border of the sternocleidomastoid muscle or just beneath it along the course of the jugular vein. Pemberton³¹ contends that lymph flow is centrifugal and few, if any, tumors metastasize into the thyroid gland. If such metastasis does extend into the thyroid, it must travel by blood vessel invasion, and not through the lymphatic channels.

When such nodules first appear in the lateral cervical area, their growth is slow and not infrequently they are construed as inflamed cervical lymph nodes. The involved cervical lymph nodes may be either single or multiple, with little evidence of involvement of the corresponding lobe of the thyroid. When such nodes are excised and reported as malignant by frozen section, hemithyroidectomy of the adjacent lobe should be carried out immediately

en bloc, with a radical neck dissection. The involved lobe of the thyroid may harbor a very small, or a rather large tumor, and must be investigated to determine if it is the origin of the metastatic emboli. The significance of this observation is shown by the following two case reports.

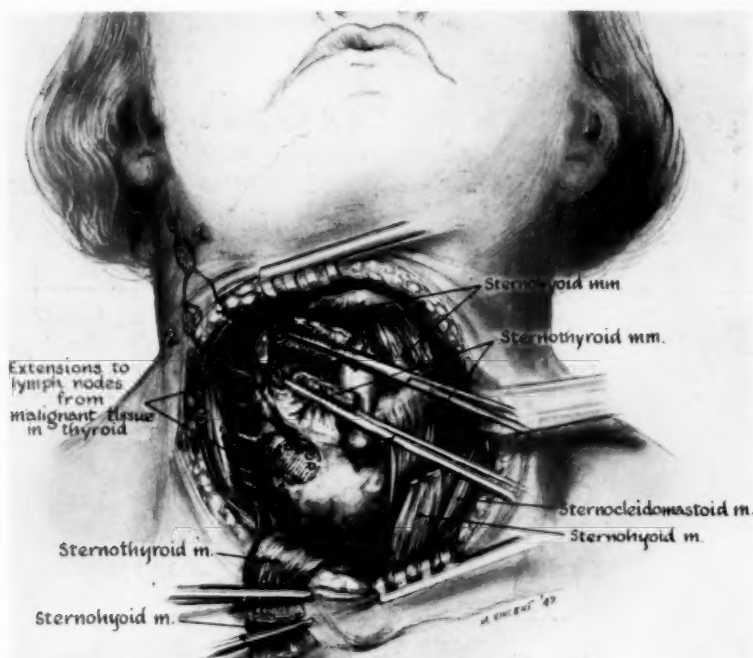
A 48-year-old white female had nodules removed from the right lateral cervical area on two occasions over a period of 10 years (Fig. 3). Pathologic



FIG. 2.—Papillary carcinoma of thyroid gland. (A) Male child, four years of age; history of adenoma in right lobe since patient was six months of age. This began active growth two years ago. There is deviation of trachea to the left. The tumor is nodular; some areas are hard, others are soft and cystic. (B) Cross-section of tumor. Multiple cysts; some areas of tissue are firm; others containing papillary projections extending into cysts. (C) Photomicrograph. Papillary growths covered with epithelium which is several layers thick in some areas. Growth has penetrated capsule.

diagnosis on each occasion was carcinoma of thyroid tissue. The patient returned in answer to a follow-up letter, at which time there were other nodules in the lower right cervical area, measuring about 1.5 or 2 cm. in diameter. The nodes were discrete, firm, and partially fixed. The thyroid gland, on examination, was apparently normal. At operation, a small tumor was

A female patient, 31 years of age, was referred for irradiation following removal of discrete malignant thyroid tissue masses in the cervical nodes on



two occasions at four month intervals (Fig. 4). Nodes in the left lateral cervical area previously removed had been diagnosed as papillary carcinoma of lateral aberrant thyroid tissue. On admission, a moderate-sized adenoma was present in the left lobe of the thyroid, together with discrete enlarged lymph nodes in the lower left lateral cervical area. A hemithyroidectomy and

left radical neck dissection were done. Papillary adenocarcinoma was found in the lobe of the thyroid tissue; also in the lymph nodes.

It is not unusual for a small sclerotic adenoma, showing malignant degeneration, to be situated in the posterior medial position of the thyroid, and therefore difficult to detect before operation; and, even at operation, unless the lateral thyroid vein is ligated and severed, and the lobe rotates medially.

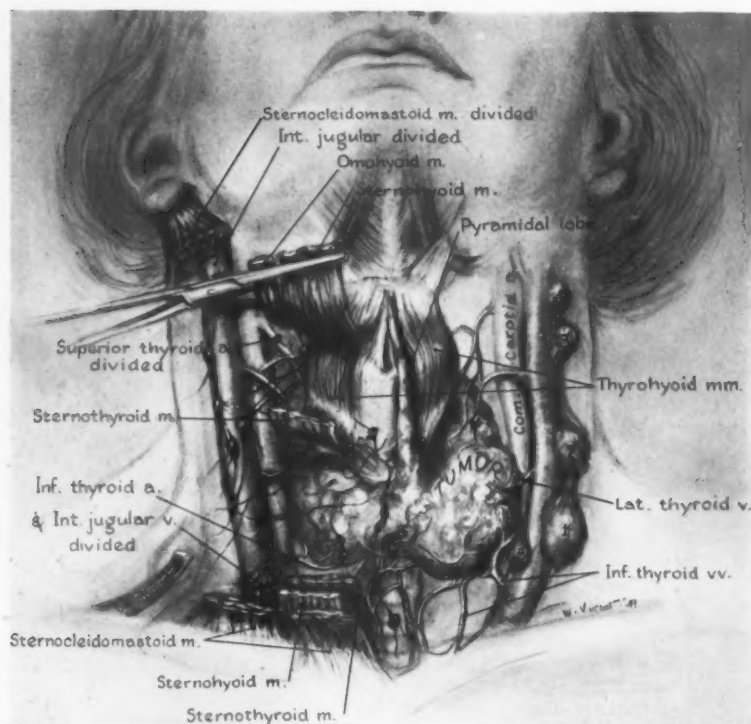


FIG. 4.—Artist's conception of papillary carcinoma involving the left lobe of the thyroid gland with metastases to the jugular chain of nodes. Discrete nodes have been removed in positions 1 and 2, on two different occasions before patient was referred to our clinic. The diagnosis had been papillary carcinoma of aberrant thyroid tissue on each of the two occasions. Examination revealed a firm tumor in the left lobe of the thyroid gland with discrete enlarged nodes that showed metastases at 3, 4, and 5. Hemithyroidectomy; radical neck dissection. Pathologic examination of tissue revealed papillary carcinoma of the thyroid with metastases to the jugular chain of lymph nodes.

Such tumors may be degenerated, calcified, and fibrosed, but continually disseminating metastatic emboli to the node-bearing area.

Group II.—Moderate Grade of Malignancy. This group, consisting of papillary adenocarcinomas, alveolar adenocarcinomas, and Hürthle cell carcinomas, are of moderate grade of malignancy (Fig. 5). They commonly arise from within an adenoma, or may develop from a portion of gland that is free from an adenoma. The histologic picture shows a less differentiated type of

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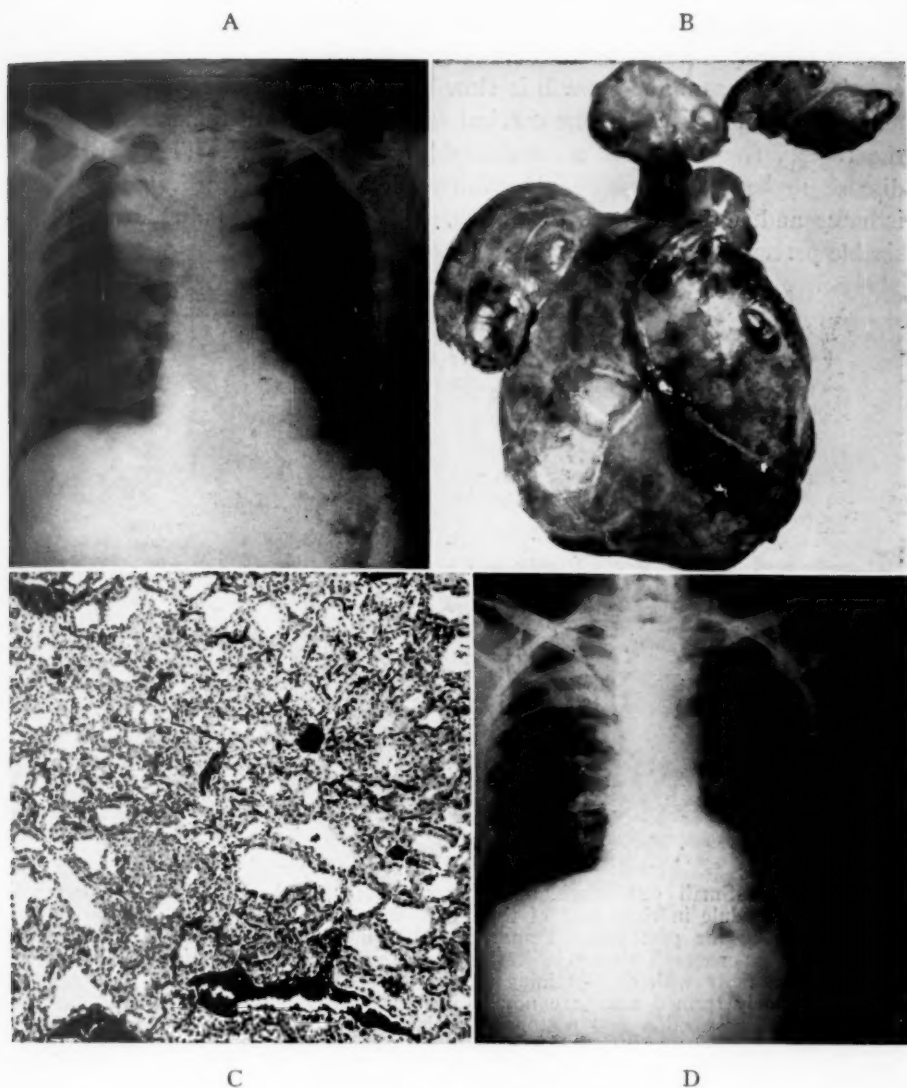


FIG. 5.—Intrathoracic Hürthle cell carcinoma, thyroid gland. (A) Female patient, 36 years of age, with a history of adenoma, right lobe of thyroid, for several years. This disappeared six years ago, following iodine medication. Afterwards patient developed choking attacks and asthma, and was unable to sleep on her right side. Roentgen ray examination of chest reveals diffuse tumor extending to below the arch of aorta. (B) Tumor after removal. Small cervical tumor present with stalk extending to large tumor that was entirely within the thorax. (C) Photomicrograph showing epithelium forming poorly developed acini, containing watery type of colloid. Epithelial cells are large. Clear cytoplasm. Characteristic of Hürthle cell type of carcinoma. (D) Roentgenogram of chest two years after removal shows no evidence of recurrence.

growth than Group I and with a greater variability of the epithelium in size and shape, and having moderate mitotic activity. These types of tumors may invade the capsule early, extending to the adjacent thyroid and surrounding tissues. It may develop to such an extent as to destroy all evidence of a pre-existing adenoma. The growth is slow and even after its capsule is invaded and it has metastasized to the cervical nodes, the growth remains localized to the region, frequently for a considerable period of time. This permits the disease to be eradicated by a hemithyroidectomy with the removal of the isthmus and a radical neck dissection, with a resultant nonrecurrence in a sizable percentage of cases.

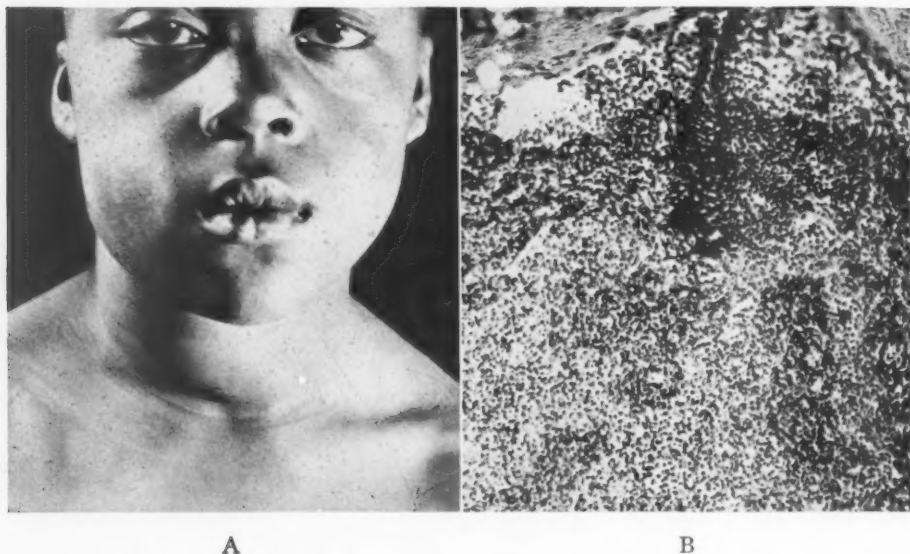


FIG. 6.—Small cell carcinoma, thyroid gland. (A) Eight-year-old male; history of nodule in right lobe of thyroid of four years' duration. Rapid growth began during the past year. Tumor, nodular, immobile, measures 4 by 6 cm. (B) Photomicrograph shows infiltration with small round cells, varying in size and chromaticity with dark-staining nuclei. One edge of the capsule is present. A few poorly formed acini are noted. Hemithyroidectomy was performed, with radical neck dissection and postoperative irradiation. There was no recurrence after five years.

Group III.—High Degree of Malignancy. This group of tumors presents a wide variety of histologic patterns and simulates the cellular changes observed in tumors of high histological grades encountered elsewhere in the body (Fig. 6). Fortunately they compose a small percentage of thyroid malignancies. They may have their origin either within a pre-existing benign adenoma or arise from a non-goiterous gland. Their growth is rapid; the adjacent tissues are quickly invaded with metastases to the regional and distant nodes. They present a bizarre type of histology with all the extremes represented. They are so anaplastic that it is at times difficult to distinguish

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them from sarcoma; both clinically and histologically they may resemble thyroiditis, especially of the Hashimoto variety. Clinically the hardness of the tumor may suggest Reidel's struma.

Criteria of Malignancy. Blood vessel invasion is the most characteristic feature in determining thyroid cancer. The malignant adenoma and papillary carcinoma are the common types of thyroid malignancy. The clinical course of these tumors is in keeping with their low histologic Grade of I or II, on the basis of I to IV, as developed by Broder.^{5, 6} Factors, as the extent of vascular invasion, both microscopic and gross invasion of the veins and the capsule, the compactness of growth within the tumor, and the ease with which metastatic emboli may be broken off, are of value in determining the degree of malignancy. Clinical findings must be correlated with the histologic picture in evaluating thyroid malignancy, as in other organs of the body. This is also true of the higher grades of malignancy, as Hürthle cell, alveolar, and more anaplastic types of cellular differentiation. Mitotic activity is significant in the more anaplastic types.

The problem of a discrete fetal or encapsulated adenoma has been discussed so extensively as a causative factor of thyroid cancer that it is well to give a résumé of Allen Graham and Shields Warren's findings, as they have made an extensive study of this subject.

Adenomas are completely encapsulated masses, occurring discretely in a normal or hyperplastic gland, with histologic appearance varying from the normal architecture of the gland. The usually complete encapsulation may be broken when cancer has developed. There is a homogeneous texture, grossly and microscopically, throughout the adenoma, with frequent areas of calcification, fibrosis, and degeneration. The surrounding normal thyroid tissue may be compressed. Several variations in the adenoma are noted:

1. Growth may be made up of closely packed cells, with or without much stroma, and with little evidence of alveolar formation and no colloid.
2. The second type of adenoma is more differentiated and contains numerous fetal follicles, which may or may not contain varying amounts of a watery type of colloid. Cystic changes in areas of degeneration and hemorrhage may be encountered.
3. Another type is termed a *simple adenoma* with well-differentiated thyroid tissue and has rather abundant stroma. It is definitely encapsulated and separated from the surrounding tissue and may have some functional activity.
4. The last type of adenoma is also definitely encapsulated and shows normal-looking follicles, containing normal-appearing colloid in varying amounts. It may simulate the remainder of the thyroid tissue, except that it is definitely encapsulated.

The lymphatic system of the thyroid gland was carefully worked out by Rouviere and Most.³⁵ It is important when considering the problem of cancer. The lymphatic channels begin as a rich, delicate network around the thyroid follicles and extend peripherally through the gland into collecting

trunks which drain into six groups of nodes. The multiplicity of directions of lymphatic flow from the various parts of thyroid gland account for the extensiveness of node metastases. If possible, the area of the gland that is primarily involved should be determined to evaluate the probable extension of metastases (Fig. 7).

Metastasis from thyroid malignancy. Metastases may develop by the blood stream or the lymphatic channels from malignant adenoma. It is not infrequent to see metastasis to a lung and osseous system or other structures develop via blood stream before clinical signs of cancer are noted in the

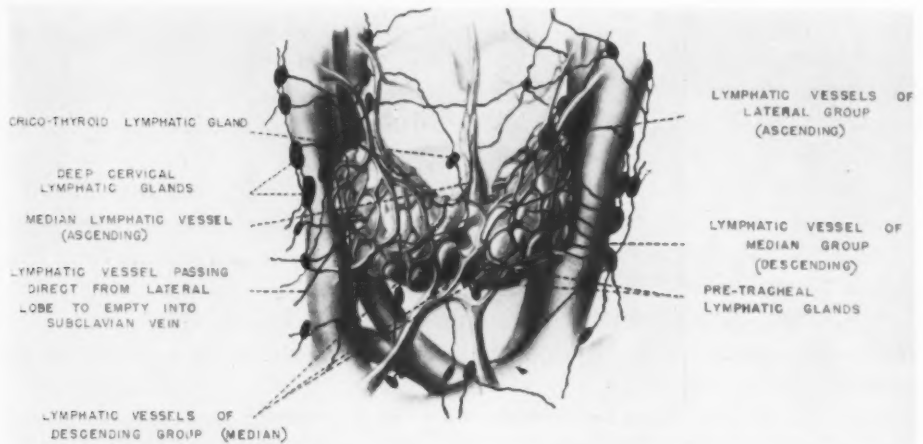


FIG. 7.—Lymphatic drainage of thyroid gland. Note that tumors arising from the isthmus medial half of the lateral lobes have a bilateral anastomosis of the lymphatic channels. Those rising from the superior medial areas of the lateral lobes and isthmus may involve the lymphatic nodes over the thyroid cartilage or the nodes in the suprasternal notch and anterior mediastinum. (Re-drawn from Rouviere. Edwards Publishing Co., Ann Arbor, Mich., 1938.)

primary thyroid adenoma. When the malignant adenoma has infiltrated its capsule, metastases then occur through the lymphatic channels to the regional or distant lymph nodes.

On the other hand, the highly malignant, or infiltrative group, metastasize through the lymphatic channels, the regional nodes being involved first, and later extending to the other drainage areas. In anaplastic carcinoma elsewhere, as well as the thyroid, it is possible for metastases to spread by the blood stream, as well as the lymphatic channels.

Metastases from the malignant adenoma and papillary adenocarcinoma are first limited to the regional nodes on one side of the neck. Because of their slow growth and low histologic grade, it is not unusual for these patients to live in relatively good health with cervical or mediastinal nodes for a number of years. These tumors may recur five or ten years or longer after their apparent cure.

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In this group of cases, the regional nodes were involved in 17 (85 per cent) of the 20 cases of papillary adenocarcinomas. The regional nodes and, in many instances, distant nodes were the seat of metastases in 39 cases (34.8 per cent) of the entire series of 112 cases; in eight cases there were metastases to visceral structures (the lung most frequently involved) and to the osseous system in six cases. The anaplastic type of tumor metastasized to the regional and distant nodes, the osseous system, and the lung in three cases. All metastases from a malignant adenoma and papillary adenocarcinoma were limited to one side of the neck.

Symptoms and clinical course of thyroid cancer. Unfortunately, early thyroid cancer produces no definite symptoms or signs; however, there are suggestive findings which will assist the alert physician to a tentative diagnosis. In view of the fact that over 80 per cent of thyroid cancers are preceded by adenomas, changes in either a discrete adenoma or an adenomatous goiter are significant. In most cases, the patient will notice a lump in the neck, either in the region of the thyroid gland or in one of the lateral cervical areas; and, if intelligent, will seek professional aid immediately. The lump may represent a benign adenoma, an adenoma that has undergone malignant change, metastases in the lateral cervical area, or a malignancy developing in a non-goitrous gland. In this series, the average duration of the nodule before the patient consulted the clinic was 3.8 years. The shortest time was two weeks, and the longest was 38 years—the patient having had an adenoma that became malignant.

Patients with a discrete adenoma or bilateral adenomatous goiter that shows recent increase in size of the goiter, with or without a sense of pressure in the neck, should have a careful examination to determine whether cancer is present. Bosselation and areas of hardness of an adenoma suggest malignant change. Invasion of the capsule with fixation of the tumor to the strap muscles and trachea limit its mobility. Benign tumors seldom produce sufficient pressure on the recurrent laryngeal nerve to produce functional disturbance of the cord, evidenced by hoarseness. However, malignant tumors occurring in the posterior area of a lobe or an isthmus may invade the trachea, producing pressure, or involve the recurrent laryngeal nerve with voice changes, and later fixation of the vocal cord in the cadaveric position. Lesions, such as aortic aneurysms, metastasis from branchiogenic carcinoma, or mitral stenosis, must be considered in making the diagnosis of injury or involvement of the recurrent nerves.

Sudden increase in the size of an adenoma is usually produced by intratumoral hemorrhage. Hemorrhage into an adenoma causes a sense of pressure and draws the patient's attention to the tumor's presence. The hemorrhage causes the adenoma to be tense and tender, whereas malignant change develops firmness, nodularity, and fixation. Malignant thyroids may attain frightening proportions (Fig. 8). Benign goiters slowly increase in size over a period of time, during which the structures of the neck accommodate themselves to the enlargement, the patient being oblivious of the gradual change.

One case in our series with an adenoma of long standing, undergoing malignant change, developed a hemorrhage requiring immediate aspiration and surgical excision to prevent suffocation from pressure. Occasionally, rather small adenomas measuring 1.5 to 2 cm. in diameter undergo malignant change, producing few, if any, symptoms other than a sense of tightness in the adenoma. This was observed in a colored female, 57 years of age, with a history of adenoma of 15 years' duration (Fig. 9). Examination revealed an adenoma of the isthmus of the gland that was freely movable but definitely hard in consistency and irregular in contour at one edge. When removed, papillary carcinoma with blood vessel invasion was found.

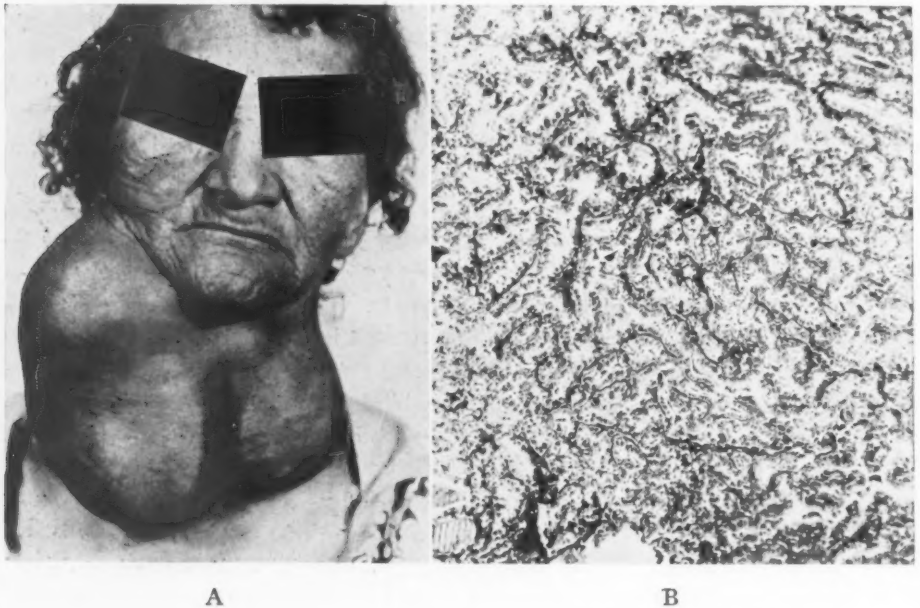


FIG. 8.—Papillary carcinoma of thyroid gland. (A) Bilateral enlargement of thyroid gland in 58-year-old white female of 18 years' duration. The right lobe began rapid growth one year ago. The chin virtually rests on the tumor and the tumor on the clavicle. There is deviation of the trachea with pressure symptoms. The tumor of right lobe is firm, with areas of hardness. The left lobe is cystic. (B) Photomicrograph shows papillary growths covered with columnar cells with basal nuclei. Some areas are attempting acini formation. Patient was well 12 years after operation, with no recurrence at that time.

Discrete or bilateral adenomatous goiters, being confined by the overlying strap muscles, are forced downward toward the mediastinum, as the chest, which is constructed similarly to an inverted cone, offers less resistance. Also a definite amount of suction develops in the lower neck with respiration. Approximately 15 per cent of discrete adenomas and a smaller percentage of bilateral adenomatous goiters become either partially or completely substernal (Fig. 5). As they descend into the mediastinum and increase in size, either

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from growth or malignancy, rather severe symptoms of dyspnea and some dysphagia results. Also discrete or bilateral adenomatous goiters, occupying the cervical position, often increase in size sufficiently to exert a definite pressure on the trachea or esophagus, with resultant displacement of these organs and consequent dyspnea and/or dysphagia.

Treatment of thyroid cancer.

The most rational treatment of any cancer is prevention, which is accomplished in thyroid cancer in most cases by intelligent handling of discrete adenomas. Approximately 80 per cent of thyroid malignancies have origin in discrete adenoma and approximately 5 to 20 per cent of such adenomas undergo malignant change. Surgical eradication of every adenoma is mandatory. The same intelligent handling and diligence should be applied to discrete adenomas of the thyroid as to the polyp of the colon and to benign lesions of the breast. Adenomas, when removed, that show no evidence of blood vessel invasion on frozen section, are classified as benign and no further treatment is indicated.

When adenomas that are removed prophylactically and, on frozen section, reveal blood vessel invasion or other evidence of malignancy, it is our policy to do a hemithyroidectomy, removal of the isthmus, preservation of the recurrent laryngeal nerve, and a radical neck dissection extending up to the digastric muscle. The neck dissection includes removal of the jugular vein, fascia containing the lymph nodes, and the medial half of the sternocleidomastoid muscle. The colla incision, made for removal of the apparently benign adenoma, is elongated up the neck along the anterior border of the sternocleidomastoid muscle to the level of the hyoid bone.

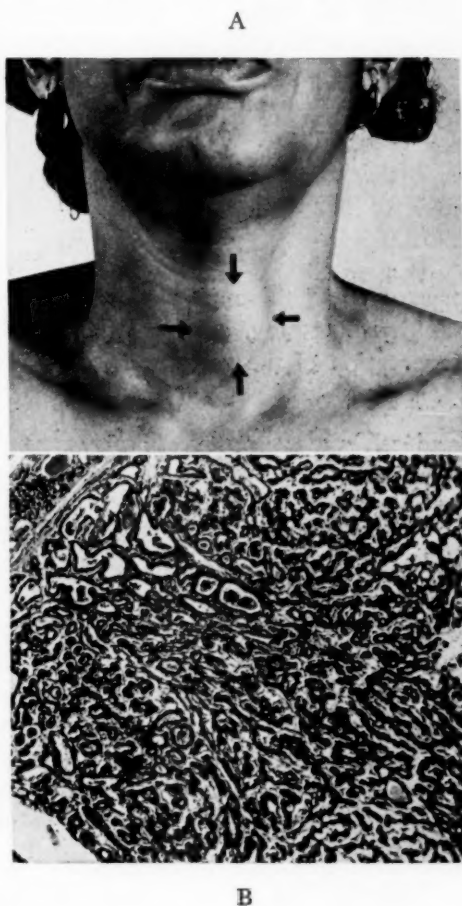


FIG. 9.—Papillary carcinoma, thyroid gland. (A) Patient, female, 57 years of age, with a history of adenoma of the thyroid gland for 15 years. In the past few weeks she noted a tenseness. Examination: Adenoma, firm, contained one or two hard areas; movable. (B) Photomicrograph. Epithelial cells forming papillations; poorly formed acini. Cells vary in size, shape, and chromaticity; capsule intact. This type of carcinoma of thyroid gland gives the best prognosis.

The operability of frank cancer of the thyroid depends upon the presence or absence of distant metastases, and extent of the primary lesion. Lesions that have infiltrated the adjacent structures; *i.e.*, strap muscles, trachea, recurrent laryngeal nerve, and perhaps the esophagus, or have extended beneath the sternum are non-resectable. Tumors that appear to be partially fixed and are movable only to a degree both vertically and horizontally, frequently are found on exploration to be resectable. Non-resectable tumors, when fixed at one or two points, should be excised as far as possible, together with the node-bearing area, even though small fragments are left attached to the trachea or esophagus, for frequently adequate postoperative irradiation gives very good results for many years.

If a lesion involves one lobe and is not too firmly fixed to the adjacent structures and there are regional cervical metastases, it is our policy to do a hemithyroidectomy, a radical neck dissection, removal of the isthmus, and preservation of the recurrent nerve, if possible.

OPERATION FOR RADICAL REMOVAL OF THYROID CANCER AND RADICAL NECK DISSECTION

The patient is prepared as for all other extensive operative procedures on the head and neck, which includes assurance of adequate supply of blood from the blood bank.

Anesthesia. For all thyroid operations, as for other extensive operative procedures on the head and neck, intratracheal anesthesia is the anesthetic of choice, because (1) adequate respiratory exchange is assured at all times, (2) there is no danger of tracheal collapse, and (3) the anesthetist is away from the operative field. Induction is accomplished by intravenous administration of pentothal sodium; nitrous-oxide oxygen mixture is administered by inhalation. The electrosurgical unit can be used for either cutting or coagulation, as desired.

Technic. The operative technic we use is essentially that developed by Lahey (Fig. 10). The usual collar incision is made and elongated up the involved side of the neck to the mastoid process. The skin flaps and platysma muscle are dissected widely. The resection begins laterally with the sternocleidomastoid muscle; in the fastidious woman the outer half of the muscle is left for better cosmetic results. The sternomastoid muscle is severed above the clavicle and below the mastoid process to give access to the internal jugular vein, which is then ligated above the clavicle and just below the mastoid process, reducing the possibility of blood dissemination. The omohyoid muscle is severed and, since thyroid cancer invades blood vessels, the jugular vein and its tributaries from the thyroid gland, together with the fascia containing lymph nodes, are rolled medially to the lateral border of the thyroid gland. The recurrent laryngeal nerve is dissected out, according to the method of Lahey. The superior and inferior thyroid arteries are ligated, preventing troublesome oozing. The strap muscles are severed from their

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upper and lower attachments. The tumor-containing thyroid lobe and isthmus are dissected away from the trachea and esophagus, if so attached, care being exercised not to injure the wall of the esophagus. The isthmus is then cut across and the entire specimen removed in one mass. If the tumor has grown posteriorly and medially, the dissection includes the periesophageal nodes.

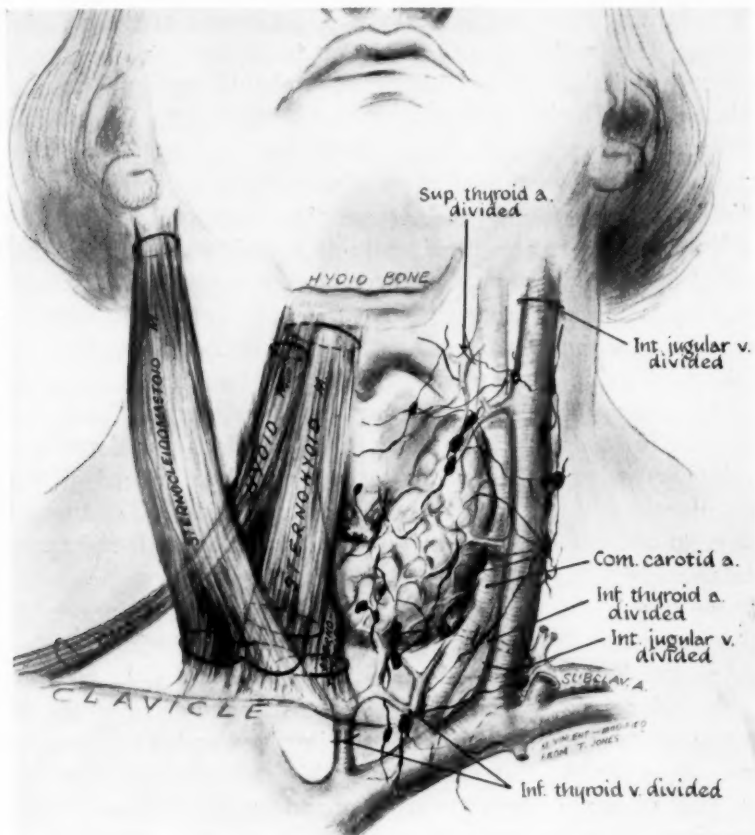


FIG. 10.—Diagrammatic illustration demonstrating Lahey's technic of radical neck dissection for hemithyroidectomy. On the right side is shown where the sternomastoid muscle is severed above the clavicle and below the mastoid process. The jugular vein is ligated above the clavicle and high in the neck. The omohyoid muscle is severed; the superior and inferior thyroid arteries are ligated. The lobe and isthmus of thyroid tissue to be removed. The drawing on the left side of the neck shows strap muscles which are to be removed from the side of the neck that is involved by the tumor.

The submaxillary nodes and suprahyoid structures are included in the dissection if there is evidence of involvement.

When the dissection is carried out along anatomic lines of cleavage, extensive growths, which may appear to be stuck, frequently can be removed completely. Lahey has stressed the importance of removing all involved tissue

that is adherent to the trachea, leaving the trachea bare. This will prevent the possibility of postoperative edema, swelling, or hematoma, so permitting irradiation to be carried out with greater ease. Lesions that have extended from the lower pole of the thyroid to involve and infiltrate the structures in the superior mediastinum are not removed surgically.

To prevent respiratory difficulty from edema of the trachea in the immediate postoperative course, a tracheostomy is performed at the completion of the operation. The tracheostomy tube is left in for four or five days, unless postoperative irradiation is advisable, when it should remain for a period of five or six weeks. During the application of irradiation, the tracheostomy tube is temporarily removed to prevent irritation from secondary rays. The tube is re-inserted immediately after completion of each sitting.

Irradiation therapy for thyroid cancer. Irradiation has proved to be a definite adjunct to the treatment of operable thyroid cancer when the lesion has extended to the contiguous structures of their regional metastases. Irradiation therapy is begun usually within ten days or two weeks after surgery, if the patient's condition permits. A cross-fire method, using three portals, one portal on each side of the neck and one in the midline, care being exercised not to overlap the field, directing the rays toward the tumor site. Treatments are given daily or three times weekly. Each portal receives 200 r units in air, per sitting, a total of 2000 r per portal, or a total of 6000 r to the neck, delivered within a period not exceeding 30 days. Treatment factors are 200 Kv, 50 cm. S.T.D. filtration 1/2 mm. Cu, 1 mm. Al, and appropriate size portals.

The same type of irradiation therapy is administered to inoperable cases and local recurrences. It has been of definite value in reducing the size of the parent lesion and holding regional metastases in abeyance. Local recurrence only in the regional nodes, with no evidence of recurrence of the primary lesion, is treated by surgical excision of the involved nodes and postoperative irradiation, as outlined. Extensive inoperable growths, either primary or recurrent, that encroach upon the trachea and/or esophagus, when treated with heavy irradiation by cross-firing from side to side, frequently develop rather severe edema of the trachea with obstruction to respiration. Such a complication may be prevented, or at least limited, by directing the beam of roentgen ray in an anteroposterior manner on each side of the larynx and trachea, so that a minimum amount of the rays actually reach these organs. After the massive primary growth recedes, then the region of the thyroid isthmus may be treated without danger of respiratory obstruction. Larger growths that have infiltrated extensively frequently require a tracheostomy before irradiation therapy is begun. Palliation may extend for months or, in an occasional case, for years, especially those of low histologic grade, as papillary adenocarcinoma.

Radioactive iodine in thyroid cancer. In recent years, the use of radioactive isotopes has opened new fields of investigation and therapy. The thyroid has a specific avidity for iodine, therefore radioactive iodine¹³¹ (so-named

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because of its atomic weight) is the isotope most frequently used. Beta and gamma rays are emitted by the isotope, causing irradiation, localized within a radius of a few millimeters around each particle.

The principles of dosimetry and general biologic effects on thyroid tissue are similar if roentgen ray, radium, or radioactive iodine irradiation are used. With radioactive iodine, if its use can be controlled, there should be less tendency to damage the surrounding normal tissues.

When ingested into the human body, radioactive iodine is concentrated almost entirely in the thyroid gland or in active metastases. The amount of irradiation delivered to thyroid tissue, wherever located, will depend on the dosage administered and the ability of the thyroid tissue to assimilate the administered iodine. J. H. Means has demonstrated that the ability of thyroid to take up iodine, and the length of time it will remain in thyroid tissue, depends upon its functional state.²⁶

It is obvious that if thyroid cancer and/or regional or distant metastases assimilate sufficient radio-isotope, and if the tumor is sensitive to irradiation, a valuable method of therapy is available, especially in widespread metastases. Many years ago, Billroth² and Von Eiselberg⁸ found that following total removal of the primary thyroid gland cancer, metastases, if present, may take on thyroid function to such a degree that a state of hyperthyroidism ensues. From this observation, it can be safely deduced that in a patient with carcinoma of the thyroid who has had complete loss of the gland either by surgical removal or destruction by irradiation, local or distant metastases involving the osseous system or viscera, if present, may take on thyroid function. Such metastases are best treated with radioactive iodine.

It has been shown that the well-differentiated follicular carcinoma and the malignant adenoma apparently have the greatest ability to assimilate and hold iodine, their metastases showing the same ability. It is estimated that only 15 to 20 per cent of thyroid cancers have functional ability, and it is this group that will receive the greatest benefit from radioactive iodine therapy. The less-differentiated carcinomas and their metastases lack the capacity to concentrate iodine, therefore they are not amenable to effective treatment with this radioactive isotope. If the histology of a thyroid cancer is known, better evaluation can be made of its ability to be effectively treated by any method of irradiation. Tracer doses of radioactive iodine may prove to be of importance in determining distant metastases from well-differentiated follicular carcinoma and malignant adenoma. The method of determining radioactive pickup is by the use of the Geiger-Müller counter or a radioautograph. The Geiger-Müller counter will determine small tracer doses of the isotope in tissues. The counter is passed over the body and registers only over areas where radioactive iodine is concentrated.

Experimental work is being conducted in several centers over the country to evaluate its efficiency, standardization of the dosage, and to determine whether there will develop any ill-effects to other systems or other organs, such as bone marrow and kidneys. A sufficient period of time will be required

to observe patients who have been treated with this modality to evaluate the good or ill-effects. F. H. Lahey, speaking before the American Goiter Association at Toronto, Canada, in May, 1948, summed up the problem by saying that the use of radioactive iodine in the treatment of thyroid cancer is a justifiable experiment, but at this time is in the experimental stage.

Prognosis and Conclusions. The prognosis of cancer of the thyroid gland will be improved by the routine removal of the premalignant lesion, the benign thyroid adenoma which is the precursor of cancer in 80 per cent of the cases. The findings of Portermann, Lahey, Hare and Warren, and Pemberton, and of the authors, substantiate the fact that the best prognosis is obtained when the evidence of malignant tumor is discovered only by microscopic examination, and the tumor is only a few millimeters in diameter.^{8, 23, 25, 29, 35, 36} A good prognosis is encountered in cases that develop from discrete or multiple adenomas. Such tumors are, as a rule, of Grade I or II histologically, and are therefore slowly growing and metastasize late.

SUMMARY

A discussion of carcinoma of the thyroid gland has been given. One hundred twelve consecutive cases treated at the Johns Hopkins Hospital have been reviewed. Only those cases admitted to pathologic study were selected. Each case has been made to conform to the clinico-pathologic grouping of the American Goiter Association. The present-day status of therapy has been discussed.

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LYMPHATIC METASTASES OF CARCINOMA OF THE COLON AND RECTUM*

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CARCINOMA OF THE COLON AND RECTUM spreads by local extension, by the blood stream, and by the lymphatics. The last channel of dissemination is the subject of this report. The lymphatic routes of spread determine to a large extent its surgical treatment. These routes have been established by the injection studies of Jamieson and Dobson,¹ Rouviere² and others and have been shown to follow the superior and inferior mesenteric vessels and their branches. Jamieson and Dobson found that the accompanying nodes fell into four main groups, epicolic, paracolic, intermediate and principal. These groups were not completely distinct and separate entities but tended to merge into each other. The lymph flow was usually first to the epicolic and paracolic nodes which acted as the first line of defense, but occasionally went by direct channels to the intermediate nodes and less often directly to the principal nodes. According to Rouviere, direct channels to the intermediate and principal nodes occur chiefly in the hepatic flexure and the sigmoid, especially the latter. Jamieson and Dobson reported that in the splenic flexure and in the distal two-thirds of the transverse colon the paracolic nodes were never bypassed. On the basis of their studies they indicated the amount of mesentery and bowel that should be removed at operation for lesions in the various segments of the colon. The epicolic, paracolic and intermediate nodes were included in these resections, but the principal nodes were usually not within reach. McKittrick³ has recently reviewed their findings and advocates somewhat more extensive resections especially in the left colon. As Gilchrist^{4, 5} has emphasized, the lymphatic spread of carcinoma of the colon and rectum is primarily embolic and, as elsewhere in the body when lymph glands become blocked by tumor cells, alternate routes are called into play. These routes are usually more circuitous and may even involve a reversed or retrograde flow. It is these alternate channels and their effect on the extent of tissue removed at operation in which we have been particularly interested. On the basis of our lymph node studies we have attempted to re-evaluate this subject in this report (Fig. 1).

In the last ten years the lymphatic spread of carcinoma of the colon and rectum has been studied in many of the specimens removed at operation. They have been cleared of fat by a modification of the Spalteholz technic. Each lymph node has been then dissected out under transillumination, sectioned, and its position charted on a drawing to show its position in relation to the tumor and the main blood vessels. By this procedure, more nodes and conse-

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quently more metastases could be found and a more accurate picture of the lymphatic spread of the tumor obtained. Up to the present time 322 carcinomas have been studied, 171 from the colon, 33 from the rectosigmoid, and 118 from the rectum. Of the 33 from the rectosigmoid, 30 were removed by anterior resection with ligation of the superior hemorrhoidal vessels and three by anterior excision and colostomy (Hartmann). This group was arbitrarily limited to tumors removed by these two procedures. Of the 118 rectal lesions, 108 were removed by abdomino-perineal resection and 10 by perineal proctectomy. The specimens were not examined consecutively, but when opportunity permitted. Over 12,000 nodes were sectioned during this study.

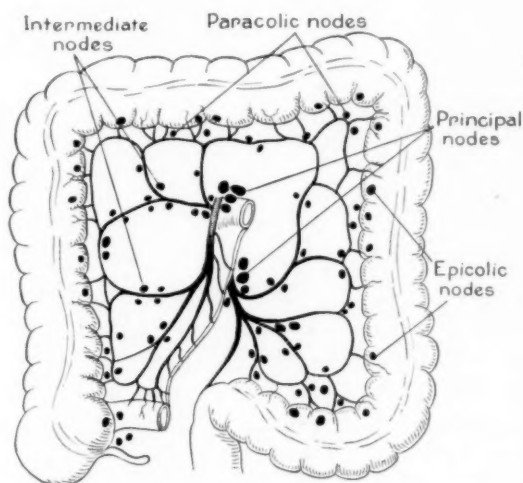


FIG. 1.—Diagrammatic drawing showing the epicolic, paracolic, intermediate, and principal lymph node groups accompanying the vessels of the colon.

It is evident that by the time the patient is operated upon somewhat less than one half (43 per cent) of the colon tumors and slightly over one half (53 per cent) of the rectal tumors have metastasized to the regional nodes. Recent studies on this same group of tumors to be published elsewhere show that one third (colon 33 per cent, rectum 36 per cent) have already invaded the veins locally near the tumor before operation. The higher incidence of lymph node metastasis in the rectum than in the colon was also found by Gilchrist and David^{6,7} and by Collier, Kay and MacIntyre⁸ in specimens studied by similar technics. When node metastases were present the average number per specimen was five for both the colon and rectum. The highest number in any specimen was 25 for the colon and 34 for the rectum.

Cecum, Ascending Colon, and Hepatic Flexure. In the right colon, grouping the cecum, ascending colon and hepatic flexure together, there were 16 specimens with lymph node metastases. In seven of these the involved nodes

were so placed that the direction of the lymphatic flow could be determined, for; and in every specimen it was found to follow the ileocolic vessel route. It was only in tumors distal to the hepatic flexure that the middle colic route began to be used. Collier, Kay and MacIntyre reported two lesions in the hepatic flexure that spread along both the ileocolic and middle colic lymph chains. In none of the specimens were we able to demonstrate with certainty metastases along the right colic artery. This may have been due in part to variability or inconstancy of the vessel itself or to our failure to identify it.

TABLE I.—Incidence of Node Metastases.

	Number of Specimens	Average Number Nodes per Specimen	Specimens with Node Metastases	Per Cent with Metastases
Colon.....	171	35	73	43%
Rectosigmoid*.....	33	28	14	42%
Rectum.....	118	45	63	53%
Total.....	322	38	150	47%
* Anterior resection 30				
Hartmann 3				

There were no specimens with retrograde spread upwards towards the hepatic flexure or along the ileum. No specimens showed lymph spread direct to an intermediate node without first involving an epi- or paracolic node. Four specimens showed involvement of the most proximal node along the ileocolic vessels.

TABLE II.—Incidence of Node Metastases.

	Specimens	Specimens with Node Metastases	Per Cent with Metastases
Cecum, ascending and hepatic flexure..	35	16	46%
Transverse.....	33	18	55%
Splenic flexure and descending.....	32	14	44%
Sigmoid.....	71	25	35%
Rectosigmoid*.....	33	14	42%
Rectum.....	118	63	53%
Total.....	322	150	47%
* Anterior resection 30			
Hartmann 3			

Transverse Colon. In the transverse colon there were 18 specimens with lymph node metastases. In ten of these the direction of lymph drainage was evident. In nine the main drainage was along the middle colic vessels irrespective of what portion of the transverse colon was involved and in one it was along the left colic vessels only. In lesions of the distal transverse colon the drainage was to the right along the middle colic vessels in two instances and to the left along the left colic vessels in the case just cited. In two lesions with extensive metastases chiefly along the middle colic vessels involving 23 and 25 nodes respectively, there was considerable lateral spread along the paracolic

lymphatics on one or both sides of the tumor, suggesting blockage of the main route and retrograde flow laterally. The need for wide excision of both bowel and mesentery in such cases is obvious. Four tumors had spread to glands in the gastroduodenal omentum close to the greater curvature of the stomach. In each specimen node metastases were excessive, 23, 25, 9 and 7 nodes respectively, suggesting that such spread is a secondary and alternate one when the main route is blocked.

One tumor of the distal transverse colon showed a single node metastasis near the point of ligation of the middle colic vessels. This represents a direct metastasis to an intermediate node and an exception to Jamieson and Dobson's contention that the epi- or paracolic nodes are never by-passed in the distal transverse colon.

Eight specimens showed involvement of the most proximal node along the middle colic vessels.

Splenic Flexure and Descending Colon. There were 14 carcinomas with node metastases in the splenic flexure and descending colon. One lesion of the splenic flexure had spread to the right toward the middle colic lymphatics as well as downward along the left colic. One tumor of the descending colon with 18 node metastases showed lateral extension both upward along the left colic and downward along the sigmoid vessels. This is another case where wide resection was especially indicated. There were no cases in this group with direct dissemination to the intermediate glands without first involving the epi- or paracolic nodes. Five specimens showed involvement of the most proximal node along the left colic artery.

Sigmoid. In the sigmoid colon there were 25 tumors with node metastases. Four of these showed considerable lateral spread of the involved nodes. All had an unusual number of metastases, 21, 13, 9 and 8 respectively, suggesting again that the lateral extension was due to a blockage of the more direct routes. Here again it is doubtful whether the resections were extensive enough. There may be several sigmoid branches of the inferior mesenteric artery supplying the region of the tumor. As the nodes along any one or all branches may be involved by tumor, all branches should be included in the area resected.

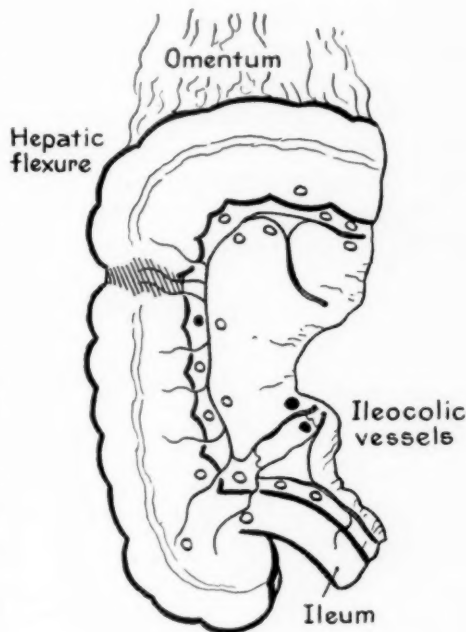


FIG. 2.—S. P. 74287. A carcinoma of the ascending colon with lymphatic spread along the ileocolic vessels.

In three specimens a metastasis passed directly to an intermediate node. In one of these a node was removed at operation for frozen section from just below the origin of the left colic artery and was found to contain tumor cells. No other involved nodes were later found in the excised specimen. This would seem to confirm Jamieson and Dobson's opinion that such direct channels are most frequent in the sigmoid.

Ten specimens showed involvement of the most proximal node along one of the sigmoid vessels.

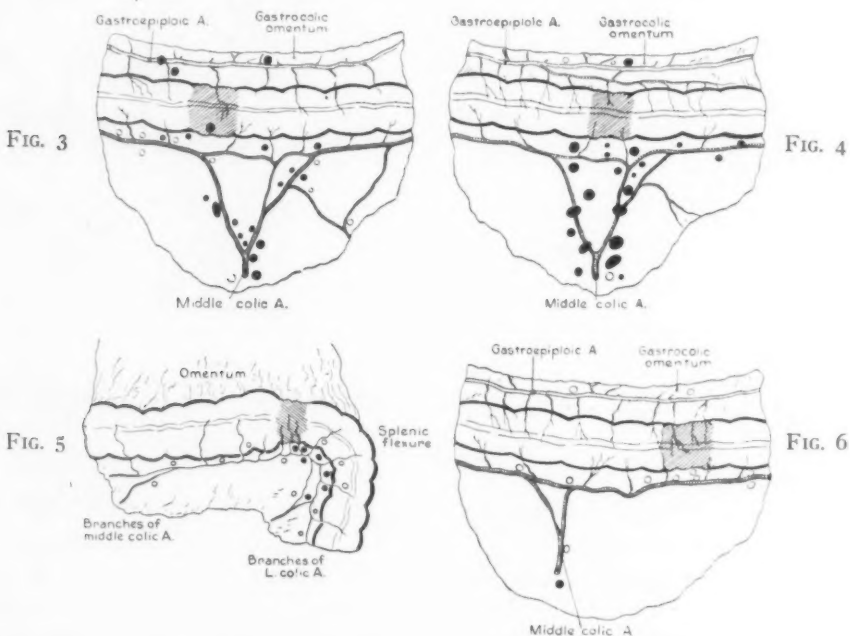


FIG. 3.—S. P. A5082. A carcinoma of the transverse colon with involvement of the middle colic nodes and of nodes in the gastrocolic omentum near the greater curvature of the stomach. There is some lateral spread distally along the paracolic lymphatics. There were 23 node metastases in all.

FIG. 4.—S. P. A9272. A carcinoma of the transverse colon with 24 middle colic metastases and one metastasis near the greater curvature of the stomach. There is lateral spread distally along the paracolic lymphatics. The excision here may have been inadequate.

FIG. 5.—S. P. 74489. A carcinoma of the distal transverse colon with lymphatic spread distally along the left colic vessels.

FIG. 6.—S. P. A5025. A carcinoma of the distal transverse colon with a single metastasis in an intermediate node near the origin of the middle colic vessels.

Recto-Sigmoid. In the recto-sigmoid there were 14 specimens with node metastases that had been removed by anterior resection and anastomosis with ligation of the superior hemorrhoidal vessels. In all the lymphatic spread was upward along these vessels with no evidence of retrograde downward spread.

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FIG. 7

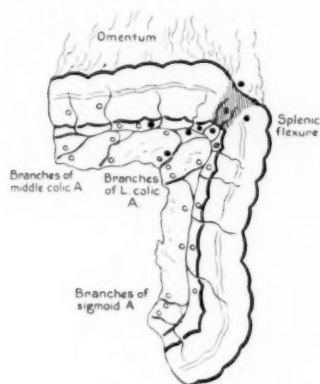


FIG. 8

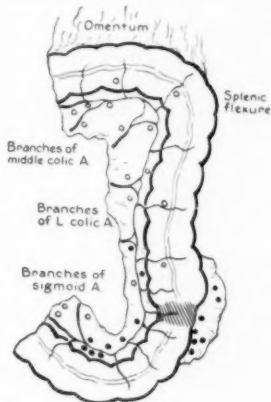


FIG. 9

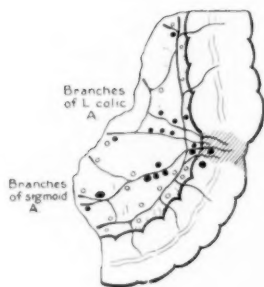


FIG. 10

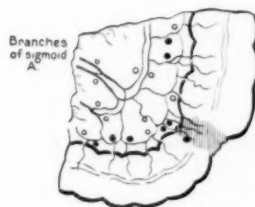


FIG. 11

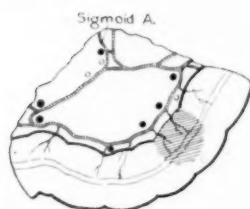


FIG. 12

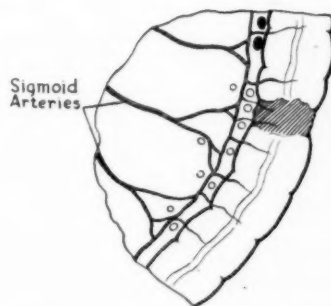


FIG. 7.—S. P. 70814. A carcinoma of the splenic flexure with lymphatic spread along both the middle colic and left colic vessels.

FIG. 8.—S. P. 73652. A carcinoma of the descending colon with lymphatic spread proximally along the left colic vessels and distally along the sigmoid vessels. There were 18 node metastases.

FIG. 9.—S. P. 70947. A carcinoma of the upper sigmoid with extensive lymphatic spread along both the left colic and sigmoid vessels. The excision is probably inadequate.

FIG. 10.—S. P. 97675. A carcinoma of the sigmoid with wide lateral spread to the paracolic nodes proximally and distally.

FIG. 11.—S. P. A4236. A carcinoma of the sigmoid with spread to the paracolic nodes proximally and distally. The excision may be inadequate.

FIG. 12.—S. P. A10218. A carcinoma of the sigmoid with spread proximally along the paracolic lymphatics. Lymphatic block was apparently not a factor in the lateral spread. The excision may well be inadequate. This is a recent specimen not included in the report.

One specimen showed a paracolic lymph node metastasis close to the proximal line of resection suggesting inadequate excision of bowel proximally. Three specimens showed involvement of the most proximal node along the superior hemorrhoidal vessels. In most of the specimens removed by anterior resection the amount of tissue and bowel resected tended to be small. Not only was this true distal to the lesion where the amount of tissue for resection was by necessity limited, but also proximally where the main lymphatic drainage occurs and where wide excision is especially important. To do an adequate cancer operation, the point of ligation of the inferior mesenteric vessels should be as high in these cases as in an abdomino-perineal resection. Lloyd-Davies⁹ has pointed out that in the abdomino-perineal operation the upper limit of

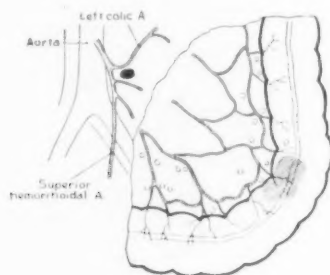


FIG. 13

FIG. 13.—S. P. A9303. A carcinoma of the sigmoid with a single metastasis in an intermediate node removed separately from above the resected area.

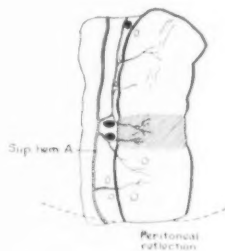


FIG. 14

FIG. 14.—S. P. 7847. A carcinoma of the rectosigmoid removed by anterior resection with a metastasis in a paracolic node close to the proximal line of resection. The area of mesentery and bowel removed proximally is inadequate.

ligation was immediately below the left colic artery in two-thirds of his cases and below the first sigmoid artery in the remaining third. In anterior resection and in other types of sphincter preserving operations a greater length of colon has to be retained and such a high ligation may be more difficult. He tests the adequacy of the descending branch of the left colic artery by compressing the main inferior mesenteric trunk and noting the point at which arterial pulsation on the bowel ceases. Greater length may be obtained by dividing the sigmoid branches just proximal to their arcades. If the middle colic vessels are sufficiently long it may even be possible to anastomose the distal transverse colon to the rectum. In 30 anterior resections Lloyd-Davies was able to ligate the inferior mesenteric trunk just below the left colic artery in one-half of the cases and below the first or second sigmoid artery in the remaining one-half. Dixon¹⁰ and McKittrick³ have also emphasized the need of mobilizing the whole descending colon and splenic flexure in many of these cases.

Rectum. In the rectum there were 63 lesions with lymph node metastases. Five of these showed evidence of retrograde downward spread with metastases

distal to the lower edge of the tumor and only one lateral spread along the middle hemorrhoidal vessels. The involved nodes occurred from 1 to 2.0 cm. distal to the tumor in the fixed specimen and in no instance were over 2 cm. distal to it. This would represent a maximum spread of about 3.0 cm. in the fresh specimen, allowing for loss by tissue elasticity and shrinkage during fixation. Although Glover and Waugh¹² claim that any downward extension to as much as 2 cm. is within the limits of normal intramural drainage, we believe these specimens do represent true retrograde spread, as they were the only ones found of all those examined, and in all of them the number of metastases was excessive, which is typical of such cases. In the five specimens the average number of involved nodes was 19 as compared to an average of five for all rectal specimens with involved nodes.

Only one specimen, previously reported,¹¹ showed definite evidence of lateral spread along the middle hemorrhoidal vessels. There were three other specimens that showed involved nodes close to the anastomosis between the middle and superior hemorrhoidal vessels which were questionable examples of lateral spread. Two of the three specimens had many metastases with probable lymphatic block. All were within 4 cm. of the pectinate line. We agree with Waugh and Kirklin¹³ and Dixon^{10, 14} that studies of lateral spread are inconclusive because of the small amount of tissue available for study. It may well be that this route is more important in low rectal tumors than previously believed. They report a poorer survival rate after abdomino-perineal resection of low rectal lesions than that following resections of lesions higher in the rectum. As they suggest, the explanation may be that the removal of both the direct extension and the lateral lymphatic spread of these low tumors tends to be limited and inadequate.

Thirteen specimens removed by abdomino-perineal resection showed a metastasis in one of the most proximal nodes near the point of ligation of the inferior mesenteric vessels. These specimens emphasize the need for ligating the vessels and removing the nodes at the highest possible level.

DISCUSSION

As shown previously in this paper, lymph node metastases occurred in 43 per cent of the colon and rectosigmoid tumors. These metastases were limited to the epi- and paracolic nodes in 25 per cent of the specimens but had reached the intermediate nodes in 18 per cent. A direct metastasis to an intermediate node without involvement of an epi- or paracolic node was found in four tumors, one in the transverse and three in the sigmoid colon. How often a direct lymph channel is present to one of the principal nodes usually out of reach of surgical excision is not known, but it must be infrequent.

Intramural extension in the long axis of the bowel in carcinomas of the colon is limited in extent and relatively unimportant. Black and Waugh¹⁶ found it never to exceed 12 mm. in 103 tumors of the left colon. The greatest spread was in the submucosa. Extramural spread, however, in the lymphatics

and especially in the paracolic lymphatics parallel to the bowel can be considerable. There were 12 lesions that showed significant spread laterally along the paracolic lymph node chain on one or both sides of the tumor. This represents seven per cent of all the colon tumors and 16 per cent of those with metastases. One was in the ascending colon, five were in the transverse colon, three in the splenic flexure and descending colon, and three in the sigmoid. There were undoubtedly others whose metastases lay beyond the limits of the excised tissue and which were not recognized. The average number of metastases in this group was 13 as compared to five for all colon cases with metastases, and illustrates how blockage of the usual drainage routes by involvement of the nodes shunts the lymph flow into more circuitous routes. There were two specimens, however, in which the lateral spread apparently could not be explained by lymphatic block unless perhaps the blocking nodes lay outside the excised specimen. The maximum lateral spread was about 13 cm. All these patients died of recurrence except for two who were operated on recently and have only been followed for a few months. It is this group in which wide removal of bowel and mesentery is especially needed. As it is impossible to recognize these cases at operation, resection should be extensive wherever possible. It may be argued perhaps that by the time lateral extension has occurred from blockage of the direct lymph channels, the principal nodes located beyond the reach of surgical attack are probably involved and the prognosis hopeless. We have no right to assume this, however.

The preceding discussion has dealt mainly with the lateral lymphatic spread. It is, however, the spread along the main lymphatic trunks that is the most important. The highest possible ligation of the vessels accompanying these trunks is needed. The most proximal intermediate node along the main lymphatic route was involved by tumor in 27 specimens from the colon, three from the rectosigmoid, and 14 abdomino-perineal specimens from the rectum, representing an incidence of 16, 9 and 12 per cent respectively or of 37, 21 and 24 per cent of those specimens with node metastases. These are the tumors that Dukes¹⁵ classifies as C2. Although the prognosis in these cases is obviously poor, yet it is by no means hopeless, as we have shown in another report to be published. These C2 cases are surprisingly numerous and present a challenge to radical surgery. Certainly every effort should be made at operation to divide the vessels and their associated lymphatic trunks as high as possible, whether they be the ileocolic, the middle colic, the left colic, or the inferior mesenteric. The level of ligation of the ileocolic and middle colic arteries is definitely limited by the danger of compromising the superior mesenteric artery and vein. In the left colon, however, higher ligation than usually practised seems feasible. In tumors of the descending colon, sigmoid and rectosigmoid it may be possible to divide the inferior mesenteric artery above the left colic and anastomose the transverse or descending colon to the upper rectum or lower sigmoid. Not only should the ligation of the vessels in anterior resection be done at a higher level but also the range of the operation should be extended upward to include most sigmoid lesions and possibly some in the descending

colon. In certain advanced cases a Hartmann type of operation, with end colostomy in the transverse or descending colon, inversion of the lower bowel and ligation of the inferior mesenteric at its origin, might have a limited usefulness.

In abdomino-perineal resection for tumors of the rectum a similar extension in lymph node removal with little cost to the patient can be gained by ligating the inferior mesenteric artery at its origin, making the colostomy in the transverse or descending colon and removing all bowel distal to it. This procedure has been suggested by Dr. John S. Lockwood. Examination of

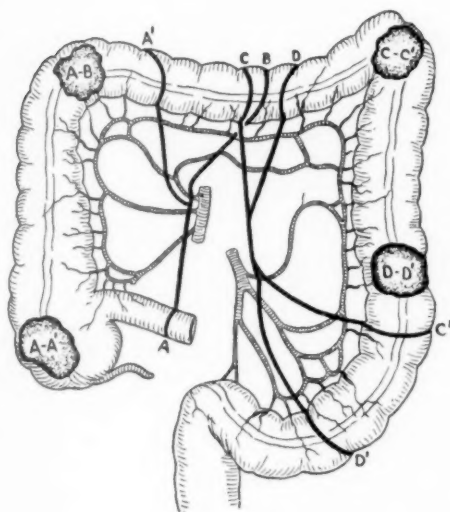


FIG. 15

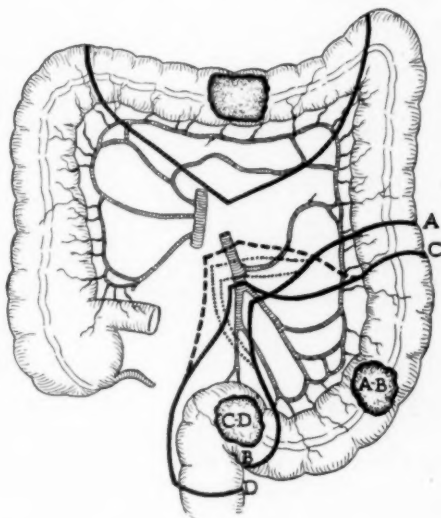


FIG. 16

FIG. 15.—Segments of bowel and mesentery to be removed for carcinoma of cecum, A-A'; hepatic flexure, AB; splenic flexure, C-C'; and descending colon, D-D'. (Modified from McKittrick)

FIG. 16.—Segments of bowel and mesentery to be removed for carcinoma of transverse colon; sigmoid colon, A-B; and lower sigmoid or rectosigmoid, C-D. Broken and dotted lines indicate alternate segments of mesentery permitting high ligation of the inferior mesenteric vessels. (Modified from McKittrick)

these specimens and their lymph nodes by the clearing technic should help to determine the advantage gained by these more radical procedures.

In the two accompanying schematic drawings adapted from McKittrick we have attempted to show what we believe to be the ideal amount of tissue and bowel that should be removed at operation for carcinomas of the various segments of the colon on the basis of our studies on lateral lymphatic spread. The areas suggested for resection are similar to those advocated by him except for some minor differences. The suggested procedures involving high ligation of the inferior mesenteric artery in certain tumors of the left colon, recto-sigmoid and rectum are also indicated. A true cancer operation calls for an attempt at complete eradication of the disease with its local extensions, its

lymphatic spread, and its vein involvement before embolism to the liver has occurred. Fortunately, the two latter routes run together and can be removed together. Of course, operative findings and variations in blood supply may make the ideal operation impossible or inadvisable, but usually it can be approximated (Figs. 15, 16).

In lesions of the right colon proximal to the hepatic flexure, the lymph drainage follows the ileocolic vessels and their branches. Ileocelectomy with high dissection and ligation of the ileocolic and right colic vessels should be done, care being taken to avoid injury to the blood supply of the small intestine. For lesions in the hepatic flexure and proximal transverse colon high ligation of all branches of the middle colic vessels is needed. Ileocelectomy with anastomosis well to the left in the mid-transverse colon would ensure maximum lymph and blood vessel removal. End-to-end rather than end-to-side anastomosis between the ileum and transverse colon has been used with increasing frequency in the last five years. In the transverse colon high dissection and ligation of the middle colic vessels and its branches are again indicated. If necessary both hepatic and splenic flexures should be freed. Wide bowel and mesenteric removal is indicated to offset the possibility of lateral spread. In the distal transverse colon and splenic flexure spread may occur along either the middle colic vessels or the left colic and excision should be correspondingly wide. In the descending colon and sigmoid the possibility of lateral spread when the direct routes are blocked again calls for wide removal. In the sigmoid there may be two or more sigmoid vessels and their accompanying lymphatics supplying the bowel. An adequate operation calls for removal of all these branches as well as branches of the left colic and sacrifice of the superior hemorrhoidal vessels in most cases. The descending colon and splenic flexure should be freed in nearly every case to permit adequate bowel resection and to avoid tension on the anastomosis. Moreover, as McKittrick has pointed out, the anastomosis can then often be done outside the abdomen more easily and more safely. In the rectosigmoid, when removal of the tumor is done by anterior resection, there should be no compromise as to the level at which the inferior mesenteric vessels are divided. It should be done as high as local conditions will permit. High ligation will ensure maximum lymph node and vein removal and adequate bowel excision proximal to the tumor. The descending colon and splenic flexure should be freed if necessary. Distal to the tumor as much bowel and retroperitoneal tissue as possible should be removed, preferably to 5 cm. and more if possible. There is usually a tendency to resect somewhat less retroperitoneal tissue than bowel because of the difficulties of exposure deep in the pelvis. It is, of course, the latter with its lymphatics and blood vessels which is the most important, provided excision is wide of the tumor itself. Using a minimal margin of 3 cm., Dixon¹⁰ has recently reported a large series followed five years with most encouraging results. The question as to what constitutes a safe margin distal to the tumor has still to be finally decided.

Other procedures suggested for carcinomas of the left colon, rectosigmoid, and rectum with high ligation of the inferior mesenteric artery at its source have already been discussed.

SUMMARY AND CONCLUSIONS

1. A study of lymph node metastases by a modification of the Spalteholz technic was made in 322 specimens of carcinoma of the colon and rectum. Metastases were found in 43 per cent of the colon tumors, 42 per cent of the rectosigmoid tumors (only anterior and Hartmann resections included), and 53 per cent of the rectal lesions.

2. The lymphatic routes of spread in the colon have been discussed. When the main routes are blocked by node metastases, lateral and often retrograde extension may occur chiefly along the paracolic lymphatics leading to more circuitous channels. Evidence of such spread was seen in seven per cent of the colon specimens or 12 per cent of those with node metastasis. There were undoubtedly other instances that were not discovered. To deal with this possibility wider routine resection of both bowel and mesentery is necessary, especially in the transverse and left colon.

3. The frequency of metastasis in the highest node along the main tributary vessels in the specimens (colon 16 per cent, rectosigmoid 9 per cent, rectum 12 per cent) emphasizes the need for ligating the vessels and removing the nodes at the highest possible level. It is suggested:

(a) that the operation of anterior resection and anastomosis with ligation of the inferior mesenteric vessels be extended upward to include tumors of the sigmoid and that the vessels be ligated as high as possible, even above the left colic branch in certain cases.

(b) that in abdomino-perineal resection for carcinoma of the rectum the inferior mesenteric vessels be ligated at their origin above the left colic branch and the colostomy be made in the transverse or descending colon.

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ENDOMETRIOSIS*

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ALTHOUGH THE CLINICAL ENTITY of endometriosis was described by Rokitansky in 1860, and although it is one of the most common conditions affecting the female pelvis, it frequently escapes detection as a cause of pelvic pain. Many patients have lower abdominal discomfort and pain for years before their endometriosis has developed to a point where the diagnosis is obvious. The frequency with which the diagnosis of endometriosis is made has varied markedly. The economic status of the patient accounts for the variation in incidence as found in private clinics and in large charity hospitals. Meigs¹⁷ believes that this variation, according to the economic status of the patient, is directly related to the frequency with which the menstrual cycle is interrupted by pregnancy. He pointed out that in the lower income group in which marriage tends to take place at an earlier age and the number of children per marriage is greater, endometriosis is much less frequently encountered. Patients in the higher income group tend to marry at a later age and to bear children less frequently, and here the incidence of endometriosis is definitely higher. Many believe that the tendency in this country toward later marriage and fewer children per marriage is directly responsible for the general increase of endometriosis.

The frequency with which the diagnosis is made varies also with the interest of the examining physician in endometriosis and the diligence with which he seeks for the signs and symptoms of this condition. Even when its frequency is appreciated and the diagnosis is considered, endometriosis often escapes detection. Endometriosis is a rare example of a benign metastasizing lesion and, because of this, the disease process may occur anywhere throughout the pelvic cavity and, to a much less extent, outside the pelvic cavity.¹⁵ Thus, the signs and symptoms may be extremely varied. Nevertheless, the study of large groups of these patients (Fallon,^{6, 7} Meigs,^{16, 17} Counseller,⁴ and others) indicates that the signs and symptoms fall into a general pattern and that there is a definite clinical picture for this disease.

With this in mind we have reviewed the records of 370 cases seen during the last ten years (1937-1948) in which a diagnosis of endometriosis was made.

ETIOLOGY

In spite of the interest of many competent observers over a period of years, the etiology of endometriosis remains obscure. Cullen⁵ has shown that adenomyosis (internal endometriosis), in which the process is limited

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to the myometrium of the uterus itself, is the result of a down growth of the endometrium into the uterine musculature. None of the theories that has been advanced to explain the etiology of true or external endometriosis adequately explains the occurrence of endometrial tissue in all the varied locations in which it has been found.

1. The implantation theory as suggested by Sampson²² has long received popular support in this country. The fact that regurgitation of endometrium through the fallopian tubes can and does occur, that viable endometrium can be transplanted to ectopic locations, and the frequency with which endometrial implants occur in the cul-de-sac has long made this one of the most plausible explanations of the etiology of endometriosis. This theory, however, does not readily explain the occurrence, occasionally reported, of extra-abdominal endometriosis, such as in the umbilicus, the lymph nodes of the inguinal region, the chest, arms and elsewhere. If, as has been suggested, endometriosis may have more than one mode of origin, this objection may not be particularly serious. The crucial point relative to Sampson's implantation theory, however, is as to whether the endometrium cast off at menstruation is or is not viable. Sampson^{22, 23} has said that if menstrual endometrium is not viable, his theory had best be forgotten. Experimental work on this phase of the subject has not conclusively demonstrated that menstrual endometrium can be successfully transplanted.

A second theory, accepted by many at the present time, is the serosal theory of Ivanoff¹⁰ and Meyer.¹⁸ They contend that under certain conditions the serosal cells of the peritoneum, which are derived from the same embryonic tissue as the endometrium of the uterus, may undergo metaplasia and produce tissue which is histologically identical with normal endometrium. Meigs¹⁷ believes that the varied hormonal reactions associated with repeated menstrual cycles probably stimulate the celomic epithelial cells to grow and produce müllerian, hence, endometrial tissue. Te Linde,²⁵ however, believes that if the stimulus to the peritoneal epithelium necessary to the formation of endometriosis is hormonal, the overwhelming stimulus of pregnancy would favor rather than discourage the development of endometriosis. He has also pointed out that if the stimulus is inflammatory, one would expect to find endometriosis in Negro patients in whom pelvic inflammation is common, whereas endometriosis in these patients is rare. MacLeod,¹⁴ in discussing this theory, pointed out that "proof of metaplasia is lacking, and that once one admits metaplasia, anything can be explained."

The third most frequently mentioned explanation of the etiology of endometriosis is that proposed by Halban,⁹ who suggested that endometriosis was produced by the dissemination of endometrial tissue through the lymphatics. Endometrial tissue has been found in the lymph nodes of the pelvic and inguinal regions, and even in the lymphatic ducts themselves. It is the most adequate of all theories to explain endometriosis of the umbilicus and pleura. It has been suggested¹⁹ that endometriomas, wherever they occur, are the result of the endometrium taking upon itself lymphatic permeation. Te

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Linde,²⁵ on the other hand, thinks that dissemination of endometrium by the lymphatics is one of the least tenable of any of these theories, pointing out that the endometrial lesions do not follow the path of the lymphatics and the finding of endometrial tissue in the pelvic lymph nodes is rare.

Other theories, such as that of von Recklinghausen²¹ attributing endometriosis to remnants of the wolffian duct, have been largely discarded.

In summary, it is, perhaps, a combination of these theories that most adequately explains endometriosis. While most menstrual endometrium is necrotic, it is quite possible that occasional bits of viable endometrium are extruded from the fallopian tubes, and if so, they would readily account for the frequency with which endometrial implants involve the cul-de-sac and ovaries. If this tissue is capable of invading the peritoneum and implanting itself in those areas, it is reasonable to assume that it can invade the lymphatics and even the blood stream, which would account for the occasional distant metastases. Until we have experimental proof that metaplasia actually can and does occur, this theory remains plausible but unsubstantiated.

PATHOLOGY

Endometriosis most commonly involves the ovaries and the peritoneum of the pelvis, particularly the cul-de-sac, the adjacent pelvic viscera, particularly the sigmoid colon, and to a much less extent, the cecum, small bowel and bladder. Endometriosis has also been found in the appendix, laparotomy scars, the umbilicus, the cervix, the vaginal wall, ureter, hernial sac, inguinal region and the abdominal and mediastinal lymph nodes, and possibly the lungs and arms.

Of the 370 patients considered in this report, 213 were operated on and endometrial implants were found in the cul-de-sac and on the uterosacral ligaments in 137 patients. An additional nine patients had endometriosis involving the right and left broad ligaments. The left ovary was involved in 89, the right ovary in 56. In 39 patients the sigmoid and rectosigmoid were involved by endometriosis. The ileum was involved in six cases, the cecum and right colon in three, the fallopian tubes in seven, the scar of a previous laparotomy in two and the bladder in one.

PATHOGENESIS

Regardless of the origin of the misplaced or ectopic endometrium, it is identical histologically and physiologically with normal endometrium. As such, it is subject to estrogenic stimulus and becomes hyperemic and bleeds at regular monthly intervals. This produces irritation and inflammation in the surrounding tissues, with resulting cyst formation. From then on, at regular intervals, bleeding occurs into the cavity of this cyst as a result of continued ovarian stimulation. In the ovaries, the fibrous reaction on the part of the surrounding tissue is less marked, and these cysts may become quite large (chocolate cysts). The walls of these large cysts are made up largely of fibrous tissue and unless carefully studied, their endometrial origin may not

be apparent. The tendency of all these endometrial cysts in the ovary and elsewhere is to proliferate and perforate. If the perforation is gradual, adhesions form between the cyst and adjacent viscera. This in turn leads to the extensive pelvic adhesions usually associated with endometriosis. If this perforation occurs into the free peritoneal cavity it may produce signs and symptoms of an acute abdominal condition. This process of proliferation, perforation and resultant fibrous reaction in the surrounding tissue, when it involves the sigmoid colon, may result in partial or even complete obstruction to the lumen.^{1, 14} The same process in the cul-de-sac of Douglas often results in complete obliteration of the cul-de-sac and marked adherence of the rectum to the posterior wall of the cervix. Since the adhesions of endometriosis, unlike inflammatory adhesions, are associated with no distinct planes of cleavage, it is often advisable to be content with supracervical hysterectomy rather than performing total hysterectomy in carrying out radical surgery in these cases. One can then avoid a possible perforation of the rectum, knowing that the endometrial process remaining will subside following the removal of all ovarian tissue. When endometriosis affects the bladder, small bowel, cecum, umbilicus and abdominal incisions, the same process of cyst formation surrounding fibrous reaction, coalescence of cysts, perforation of cyst, penetration by endometrial tissue and further fibrous reaction occurs. The symptoms in each instance are referable to the structure involved and tend to be cyclic in character in the early phases of the disease. Later, when deformity has been produced, the symptoms may lose this cyclic characteristic and become more or less constant. In this study, the left ovary was the most common site of involvement next to the cul-de-sac, endometriosis being found in 89 patients as compared with 54 patients with endometriosis of the right ovary. We have no plausible explanation for this variation between the right and left ovary, but if generally true, it may account for the much more frequent involvement of the adjacent sigmoid colon as compared with the terminal ileum and cecum.

SYMPTOMATOLOGY

The classical picture of endometriosis is a woman between the ages of 30 and 40 who is either childless or who has had but one pregnancy and who complains of increasing dysmenorrhea. It should be emphasized that the term dysmenorrhea in these patients not only refers to the actual cramplike pain of menstruation but to pain or discomfort in various parts of the lower abdomen which is either initiated or aggravated by the onset of menstruation. The location of the maximum amount of discomfort or pain varies according to the location of the endometrial process.

In this group of 370 patients with endometriosis, the process was sufficiently mild in 157 that they could be treated by medical management without surgery; 213 were submitted to some type of surgical procedure. This represents a percentage of 57.6 who were treated by surgery. Of the surgically treated patients, the youngest was 19 and the oldest was 69 years, with

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an average age of 36.3 years. Of the conservatively treated cases, the youngest was 19 and the oldest was 52, with an average age of 32.6 years. In the surgical group there were seven patients beyond the menopause who were seen because of symptoms referable to endometriosis. In these patients, of course, the symptoms were no longer cyclic in character but were related to the distortion of the pelvic viscera as a result of the endometrial process. Only two patients in the entire group were less than 20 years of age. The largest group of patients were between the ages of 30 and 40 years (Fig. 1).

Of the 213 patients who were operated upon and in whom the diagnosis of endometriosis was verified, 36 were unmarried, and of the 177 who were married, 48.6 per cent were childless and an additional 24.8 per cent had but one child. Thus, 73.4 per cent of this group were sterile or relatively sterile.

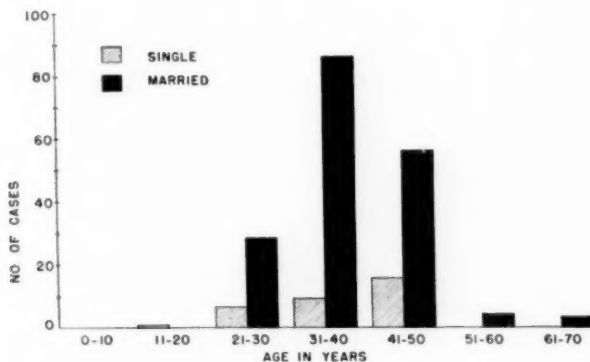


FIG. 1

This percentage of absolute sterility (48.6) may be compared with the figures of the Metropolitan Life Insurance Company which show that of married women in general, 22 per cent in this age group have no children. Of the 117 patients who were treated conservatively, the degree of sterility and relative sterility were similar in that 50.3 per cent of those patients who were married had no children and 24.8 per cent had one child.

Of the 213 patients who were operated on, 65 complained of generalized lower abdominal pain or discomfort associated with the menstrual period. Thirty-two complained only of pain in the right lower quadrant and 23 of pain in the left lower quadrant. In the conservatively treated group the figures were similar, 52 having generalized lower abdominal pain, 30 having pain only in the right lower quadrant and 33 having pain in the left lower quadrant. The only other common site of pain reference was the lower back in the lumbosacral region. Twenty-eight of the 213 surgical patients complained of low backache aggravated at the time of the menstrual period. Fourteen patients with involvement of the small or large bowel had the signs and symptoms of intestinal obstruction. These patients will be reported in some detail later. In a few patients the pain was referred to such areas as

the right inguinal region, the rectum, and the epigastrium. Eight patients had extension of pain to their right flank. In the majority of patients the pain had its onset with the beginning of the menstrual flow. In a small group it preceded the onset of menstruation, and in a still smaller group it persisted for several days following the cessation of the menstrual period. Those patients with advanced endometriosis had more or less constant lower abdominal discomfort throughout, which was aggravated at the time of menstruation.

In summary, therefore, we found that 120 patients, or 56.3 per cent of those treated surgically complained of generalized or localized lower abdominal pain aggravated or initiated by the onset of menstruation, and this constituted the outstanding symptom in this group of patients.

Most of the recent literature has emphasized acquired or secondary dysmenorrhea as a prominent symptom of external endometriosis^{7, 20}. We found that in this group of 213 surgically treated patients, 104, or 48.3 per cent, could be classified as having acquired dysmenorrhea. A much smaller group of 17 patients sought medical advice because of what could be classified as primary dysmenorrhea which finally became so severe as to force them to seek medical advice. This group of 17 patients with primary dysmenorrhea due to endometriosis is of interest, for it indicates that although the dysmenorrhea of endometriosis is usually of an acquired type, the fact that the patient states she has "always" had dysmenorrhea does not rule out this diagnosis. Fallon has called attention to the fact that endometriosis can and does occur in young women. With this in mind he has suggested that all young women being operated on for appendicitis should have a midline incision so that the pelvis can be visualized and checked for the presence of endometrial implants.

Although the importance of menorrhagia and metrorrhagia has been emphasized in the recent literature, in this series of cases only 53 patients could be classified as having either menorrhagia, metrorrhagia, or a combination of the two. This figure represents only 23.5 per cent of those treated by surgery, and of this number there were 22 patients who had associated fibroids. Whether the endometrial condition or the fibroids were the cause of irregular menstrual bleeding could not be determined. It might also be added that one patient in this group had an associated carcinoma of the fundus of the uterus, which undoubtedly was the responsible factor for her menorrhagia. Dyspareunia, although often described as a classical symptom of this entity, was of significance in only ten cases, or 4.7 per cent of those who underwent surgery. Those patients with endometriosis who have marked involvement of the cul-de-sac frequently complain of dyspareunia but since the diagnosis in these patients usually can be made by pelvic examination, this symptom would not appear to be an important factor of the diagnosis of this disease.

Bladder irritability, also frequently mentioned as a symptom of endometriosis, was found to be a complaint in only 6.6 per cent of this group. This is in line with the fact that at operation the urinary bladder was found to be rarely involved by the endometrial process. The urinary symptoms, when present, consisted of frequency, nocturia, dysuria and urgency. Men-

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strual irregularity was found in 27.2 per cent. It was interesting to note in the surgical group that 48 patients, or 22 per cent of the total, had an average weight loss of 11.3 pounds. This was probably related to the severity of symptoms, since the weight loss in the group treated conservatively was much less marked. Reference has been made in the literature to the aggravation of pain in cases of endometriosis, on walking, riding or jarring. In this group of 370 patients only four patients gave such a history.

PHYSICAL FINDINGS

In this group of patients the most common physical finding was the presence of tender nodules in the cul-de-sac, along the uterosacral ligaments and on the posterior surface of the uterus. Some of these patients had tenderness and thickening along the uterosacral ligaments without actual nodularity. These findings were present in 112 of the entire group of 370 patients. In 15 patients this was associated with fixed, third degree retroversion of the uterus. The next most common pelvic finding was ovarian enlargement. This

TABLE I.—*Significant Factors in Diagnosis of 370 Patients.*

	Both Surgical and Conservative		Surgical Only (213 Cases)	
	Number	Per Cent	Number	Per Cent
Sterility or relative sterility.....	218	58.9	157	73.7
Primary dysmenorrhea.....	45	12.2	17	7.9
Secondary dysmenorrhea.....	238	64.3	104	48.8
Significant pelvic findings.....	152	41.1	184	86.4

was present in 25 patients. It was more frequently found on the left side than on the right. One hundred and one patients had associated fibromyomas of the uterus (Table I).

DIAGNOSIS

The diagnosis in the 213 operated patients in this group was made in 118 patients previous to operation. In other words, 55 per cent of this group were diagnosed properly as endometriosis prior to surgery. We believe that this figure can be improved and the diagnosis of endometriosis be more readily established if the clinical picture of this condition is kept in mind; (1) a history of secondary dysmenorrhea, usually increasing in severity; (2) the presence of tenderness, nodularity or thickening in the cul-de-sac of the region of the uterosacral ligaments, or the presence of ovarian enlargement, and (3) a patient who is sterile or who has not borne children for a number of years (Table I).

TREATMENT

In many patients with endometriosis, symptoms are relatively mild and can be controlled by medical management. Often simple reassurance is sufficient. Others may require mild sedation. Good results have been reported

following the use of stilbestrol in the conservative management of endometriosis, although the use of estrogens has appeared to be contraindicated in this disease.^{8, 13} If it is used we believe the qualifications suggested by Hurxthal and Arnold should be kept in mind.^{11, 12}

"In cases of endometriosis it is believed that continued diethylstilbestrol therapy is contraindicated if there is a strong family history of cancer, if uterine fibroids are present, and if there is a suspicion of carcinoma. All patients receiving diethylstilbestrol should be advised to keep a careful record of any vaginal bleeding. Endometrial biopsies and vaginal smears should be examined at intervals."

One hundred and fifty-seven out of the 370 patients reported in this group were treated without operation. It should be pointed out, however, that regardless of the severity of the symptoms the presence of ovarian enlargement or a mass of any appreciable size in the cul-de-sac, particularly in a patient over 40 years of age, should always raise the question of ovarian carcinoma. It is questionable whether patients with these findings should ever be treated conservatively.

We believe that another contraindication to the conservative management of these patients is evidence of intestinal obstruction, such as involvement of the ileum or the sigmoid colon.

In this group of 370 patients, 213 or 57.6 per cent were treated by surgery. It is in these patients who, either because of the severity of their symptoms or the extent of their pelvic findings, must be operated upon, that the main problem in the treatment of endometriosis arises. It is an accepted fact that removal of all ovarian tissue will result in complete cessation of any further progress of the disease, since all estrogenic stimulus is thus removed. It is obvious that symptoms due to the presence of large chocolate cysts in the ovaries, or distortion of the uterus and other pelvic viscera by endometrial adhesions, will require surgical correction of these conditions in addition to the removal of the estrogenic stimulus. The chief surgical problem has always been as to whether or not castration is necessary in patients with extensive endometriosis, since no surgeon wishes to produce an artificial menopause, particularly in a young patient, unless absolutely necessary. There is an increasing tendency in recent years toward the use of conservative operative procedures for these patients and the avoidance of castration. One must always remember, however, that a too conservative procedure may necessitate a second operation in order to relieve these patients of their symptoms. In the past^{2, 3} we have felt that, in general, patients under 40 years of age should be treated by a conservative type of operative procedure and those over 40 should have removal of all their ovarian tissue. It should be emphasized, however, that each patient is an individual problem, with castration to be decided for or against depending upon a number of varying factors.

Keeping in mind that the average age at the menopause in this country is between 47 and 48 years, the age of the patient, plus the presence or absence of such symptoms as hot flashes which might indicate a beginning meno-

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pause, is important. The emotional stability and personality of the patient play an important role in this decision, because of the marked variation in the severity of symptoms following artificial menopause. The desire for and the probability of further pregnancy must be taken into consideration. The extent of the disease process also is an influencing factor in this decision, although extensive disease in itself is not necessarily an indication for castration. In this connection it is of interest that Meigs¹⁷ has advocated resection of the colon rather than castration in young women who have endometriosis of the bowel. Although in young patients there will be instances in which this is so, the majority of patients with extensive involvement of the sigmoid colon by endometriosis will be best treated by bilateral oophorectomy.¹

The majority of our patients, either because of severity of symptoms or the extent of the disease process, were submitted to radical surgery; 137 or 63.9 per cent of those operated upon had removal of all ovarian tissue in addition to a hysterectomy. Nine patients in this group of 137 patients who

TABLE II.—*Results of Radical Surgery.*

	Number	Per Cent
Excellent.....	121	88.3
Fair.....	9	6.5
	(6—constitutional instability)	
Poor.....	5	3.7
	(3—constitutional instability)	
Deaths*.....	2	1.4
Total.....	137	

* One of pulmonary embolus, one of renal suppression following transfusion.

were submitted to radical surgery had already had one ovary removed before admission to the clinic. Their pelvic symptoms had been unrelieved by their previous oophorectomy. One postmenopausal patient, previously referred to, had radical surgery because of carcinoma of the fundus and the endometriosis was incidental. Fifty-nine, or 43.1 per cent, of this group of 137 patients were under 40 years of age, and 78 patients, or 56.9 per cent were over 40 years of age. This is the over-all picture for the ten-year period. In recent years the percentage of patients under 40 years of age submitted to radical surgery has definitely decreased. End results following radical surgery for endometriosis, that is, following the removal of all ovarian tissue, have been excellent (Table II).

Seventy-six of the group of 213 patients who were submitted to surgery had some type of conservative operative procedure. In other words, both ovaries, one ovary, or a portion of one ovary were preserved. The type of conservative surgery varies according to the symptoms and pelvic findings. Large chocolate cysts, of necessity, need to be removed. Fixed, retroverted uteri need to be mobilized and suspended, and in so far as possible, all endo-

metrial cysts should be excised. When there is any question relative to the disease at the time of operation, frozen section should be carried out immediately before a decision is made relative to the surgical procedure that is to be followed. Endometriomas, in those specimens submitted to the pathologist, should be well marked to avoid negative reports. When the pain of dysmenorrhea is central in character rather than lateral, and is of marked severity, presacral neurectomy is usually carried out in conjunction with removal of endometrial implants. If presacral neurectomy is done, it is carried out first to avoid implantation of endometrial tissue in the retroperitoneal space. Of the 76 patients undergoing conservative surgery, 24 were subjected to presacral neurectomy and in all instances but one the results were excellent. The one fair result could be attributed to a marked degree of emotional instability.

The end results of the entire group of 76 patients in which conservative surgery was used were as follows: 67 patients, or 88.1 per cent had excellent results. In other words, they were completely relieved of their symptoms. Six, or 7.9 per cent, had fair results. These patients were improved, but

TABLE III.—*Results of Conservative Surgery.*

	Number	Per Cent
Excellent.....	67	88.1
Fair.....	6 (3 neurotic)	7.9
Poor.....	3 (2 neurotic)	4.0
Total.....	76	

continued to have some persistent lower abdominal distress of minor degree associated with their menstrual periods. It was definitely felt that in three patients a functional element was at least partially responsible for their symptoms. Three patients, or 4.0 per cent, were classed as having a poor result, since they were not improved following surgery. In two of these three patients a decided functional element was present (Table III). All of the patients in this group were followed for at least one year, with an average follow-up of two and a half years, following conservative surgery. The 88.1 per cent excellent results after conservative surgery are in keeping with our impression that an increasing number of patients with external endometriosis should have conservative surgery, particularly if they are under 40 years of age.

Some patients who, for one reason or another, could not (because they were poor risks) or would not be operated on, were treated by roentgen ray therapy with very satisfactory results. We do not believe that roentgen ray therapy is the treatment of choice for three reasons: (1) it does not permit the preservation of ovarian function, (2) in patients with extensive adhesions and distortion of the pelvic viscera it may aggravate the pelvic discomfort, and (3) patients with ovarian and cul-de-sac masses should have histologic confirmation of their diagnosis to rule out carcinoma of the ovary.

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In the entire group of 213 surgically treated patients there were two deaths. One patient died of a pulmonary embolus on her fifteenth postoperative day as she was about to go home following an uneventful convalescence; the second patient died of renal failure following a blood transfusion reaction.

CONCLUSIONS

1. Endometriosis is one of the most common conditions affecting the female pelvis, particularly as seen in private or clinic patients.
2. None of the suggested theories as to the origin of endometriosis has been conclusively demonstrated. It may be that a combination of two or more of the existing theories will best explain all manifestations of endometriosis.
3. The diagnosis in symptomatic endometriosis can usually be made if the clinical picture of this disease is kept in mind.
4. The surgical treatment of endometriosis should be individualized. The 88.2 per cent excellent result following the use of conservative surgery in this group is in keeping with the trend toward conservatism in the surgical treatment of endometriosis.

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THE SURGICAL TREATMENT OF FAMILIAL POLYPOSIS OF THE COLON*

A REPORT OF SEVEN CASES, SIX IN ONE FAMILY

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LOS ANGELES, CALIF.

THERE IS LITTLE DOUBT in the minds of surgeons who have had experience with familial polyposis of the colon that it is a grave disease which calls for radical surgical intervention without delay. The early writings about this disease show a transition from the early helplessness and temporizing measures to the recent writings which exhibit numerous surgical opinions, mostly concerned with staged colectomy and whether or not to preserve the rectum and anus. The problem that is paramount is whether or not the colon can be removed safely in one stage, and whether or not the rectum can be preserved and anastomosed to the ileum. We must determine whether or not we endanger the life of the patient, either immediately or in the future, if these principles are accepted. My experience with the seven patients reported here leads me to believe that a safe and standardized surgical treatment for familial polyposis of the colon can be adopted. The cases of one-stage colectomy with preservation of the rectum reported by Wangensteen²⁹ (for ulcerative colitis) and by Gardner⁷ (for polyposis) lend convincing support to this idea.

Excellent reviews of the history of polyposis of the colon were published in 1928 by Hullsiek¹² and by Dukes⁵ in 1930. The recognition of familial predisposition to this disease can be fixed with a certainty to the report of Cripps,³ who reported a brother and a sister, ages 17 and 19, with polyposis of the colon. The most accepted explanation of the familial disposition of the disease has been given by Lockhart-Mummery¹⁶ in 1934. He stated that the condition was an inheritable disease transmitted by both sexes and appeared to be a Mendelian dominant. He believed that the disease came on at the time of puberty, and never appeared in the newborn. The case of McKenny¹⁸ suggested that children may have the disease at birth. Lockhart-Mummery asserted that the adenomatosis of the colon is an example of gene mutation. When the mutation has taken place, the results appear in succeeding generations either as dominants or recessives. If a dominant, the condition will tend to occur in every generation, but if the disease is recessive, it will be seen only when both parents carry the mutated genes, and this may not occur for many generations, and the hereditary factor is very likely to be overlooked.

Heredofamilial polyposis of the colon is of such a striking nature that specimens have been seen by almost every physician, either in practice, in medical school, or in the pathology museums. Careful count of the polyps usually shows the number to exceed one thousand. In some colons the polyps

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are so close together that the normal mucosal pattern is completely hidden, the polyps being like thickened plaques arranged in orderly rows. This caused Broders¹⁴ to designate this type as "polypoidosis."

In the nearly 400 cases of familial polyposis in the literature, the disease was not apparent until puberty or later except in a very few patients. McKenny found it in an infant at two years and had good evidence to believe that it had been present at birth. Dixon⁴ saw two patients, each with polyposis at 18 months of age.

Cancer developing in heredofamilial polyposis of the colon was first reported by Handford⁹ in 1890, when he described a woman, age 34, who died of cancer of the rectum associated with intestinal polyposis. Of the 127 cases of polyposis collected from the literature by Hullsiek in 1928, 36 per cent developed cancer of the colon. In 19 patients with polyposis subjected to surgery by Dixon, there was invasive carcinoma in 26 per cent. Two of the five cases reported by Pfeiffer and Patterson²¹ were complicated by carcinoma. McKenny, who has followed carefully the history of three families over a long period, found 40 per cent of his patients had polyposis, and 38 per cent of these died of carcinoma of the colon. It is interesting to note that one of the patients dying of cancer was a 15-year-old child. Falk⁶ reports an interesting family of seven, six of whom have polyps, and at this time three have died from carcinoma. In the series reported by Guptill⁸ the father and two of his three children afflicted with polyposis died of carcinoma of the colon. The brother and sister reported by Miller and Sweet²⁰ were operated because of carcinoma complicating polyposis.

The first bold surgical attack on polyposis was made in 1901 by H. Lilienthal.¹⁵ At his first operation an ileosigmoidostomy was done, after which at the second stage, the entire colon was resected down to the point of the anastomosis. The polyps in the distal segment were not fulgurated. The patient was reported to be alive and well 19 years after the operation. Lockhart-Mummery in 1918 successfully performed the same operation, but he fulgurated the polyps in the rectal stump also. The first total colectomy with removal of the rectum also was done by Coffey² in three stages. An ileostomy was done in 1922, and in 1924, the colon and rectum were removed in stages. Since these three early cases, numerous surgeons have contributed operative procedures done in stages with varying sequence for removal of segments of the colon or the colon and rectum. Rankin²⁴ in 1930 advocated total colectomy and proctectomy with establishment of permanent ileostomy. Later (1937) he advocated ileosigmoidostomy with preservation of the rectum.²⁵ In 1939 Jones¹³ advocated early treatment of polyposis to consist of an ileosigmoidostomy followed by a one-stage colectomy down to the point of anastomosis provided the rectum could be carefully cleared of polyps. Mayo and Wakefield¹⁹ in 1936 advocated a five-stage procedure starting with fulguration of the rectal polyps, ileosigmoidostomy, two-stage colectomy, retrograde cautery of polyps through a sigmoid colostomy, and finally, closure of the colostomy. Recently in 1946 Dixon and Benson⁴ advocated a three-stage pro-

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cedure of side-to-side anastomosis of ileum to sigmoid, colectomy to the point of the anastomosis, and finally, fulgurations in the rectal segment. Multiple stage operations have been advocated by many authors.^{6, 8, 18, 19, 21-23, 27, 31} The striking feature of each plan is that it carries the burden of frequent hospitalization, great expense, and prolonged disability.

In the series here reported the operation consisted of one-stage resection of the terminal ileum and colon to the rectosigmoid with primary end-to-end anastomosis of the ileum to the rectosigmoid after preliminary preparation of the rectum and rectosigmoid by fulguration of polyps. The infrequency of this operation is surprising. The first one-stage total colectomy with preservation of the rectum seems to be that of Hickman¹¹ in 1932, although it was not reported until 1944. Gardner⁷ in 1948 reports three one-stage colectomies with primary side-to-side ileorectal anastomoses.

An outstanding recent contribution to the surgery of the colon was made by Wangenstein²⁰ in 1948. He reported eight one-stage total colectomies for ulcerative colitis with no operative mortality. At the time of colectomy four patients had end-to-end primary closed anastomoses of the ileum to the terminal pelvic colon, and the second four had ileoproctostomy with a similar type of anastomosis. My own series of seven one-stage procedures was done for heredofamilial polyposis and includes six members of one family. These will be discussed in some detail later in this report.

DISADVANTAGES OF STAGED COLECTOMY

The necessity for graded removal of the colon can be challenged by these 19 cases done in one stage without mortality. When one reviews the reported cases of colectomy done in stages, one finds there are other disadvantages in addition to the prolonged hospital stay, increased expense, and prolonged disability. Many of the patients refused the second stage operation after having a primary ileosigmoidostomy or in some cases, an ileostomy. Several writers encountered conditions at the second stage, such as abscess, partial obstruction, or adhesions, which prevented the next contemplated stage of the colectomy. There is a bad effect on the morale of other members of the family who also may have to look forward to multiple operations for polyposis. Many reported by various authors refused surgery after witnessing the trials and tribulations of a brother, sister, or parent. Finally, if for some reason there is a prolonged interval between stages of the operation, cancer may supervene and the patient will have lost valuable life-saving time.

TYPE OF ANASTOMOSIS

Whether one should employ an open or closed type of anastomosis is a question that must be decided by the habit and experience of the individual surgeon. Jones felt that a patient dying of peritonitis died not from contamination at operation, but from necrosis at the suture line. It is true that many of the deaths reported in the surgery of polyposis in the past have resulted from peritonitis. However, with the advent of intestinal antibiotics, even a

surgeon who employs the "open" type of anastomosis is well within the bounds of safety. Actually, while an adequate ileocolic stoma is necessary, one must recall that the slit of the ileocecal valve is about 1.2 cm. long, and if one can accomplish an anastomosis which is comparable in size, the function will be very adequate. Many ileocolic anastomoses of this type have trouble because of the "flail" action of the adjacent ileum and its mesentery. This twisting and turning interferes with the blood supply and patency of the anastomosis. Scarring and adhesions to adjacent peritoneum and occasionally complete obstruction occur. This complication is avoided by "tacking" the mesentery of the ileum to the posterior peritoneum proximal to the anastomosis. Several rows of interrupted sutures carefully placed to avoid hematomas in the mesentery will fix the bowel and adjacent anastomosis over the promontory of the sacrum and the low lumbar area and thus assure permanent patency of the anastomosis.

A new variation in surgical technic of partial colectomy, done on two patients with polyposis complicated by cancer, has been reported by Bacon and Smith.¹ The end-result consists of the transverse colon pulled through the preserved anal sphincter after the left half of the colon has been removed. Although some of the right colon can be reached by proctoscope after this anastomosis, it is difficult to imagine a patient with familial polyposis having a right colon free from polyps. In our cases and in many others reported there were malignant polyps in the right colon.

Another operation has been proposed by Ravitch and Sabiston.²⁶ This operation, done on dogs and later on a patient, consists of drawing the ileum through the anal opening with preservation of the sphincter. This had been done previously and reported by Wangenstein. With such a procedure one runs the risk of incontinence, which with ileal drainage, would make an abdominal ileostomy preferable.

PRESERVATION OF RECTUM

If one elects to preserve the rectum, the fulguration of every polyp in the distal segment of the colon, and the frequent inspection of this area for the rest of the patient's life is necessary. Likewise the burden of the anastomosis is to guarantee that every area of the mucosa of the rectum and terminal colon is visible for this inspection with the proctoscope. Many authors report complications from fulguration of rectal and sigmoidal polyps. Perforation, abscess, and scarring are most common. Guptill noted a marked amount of rectal scarring in one of his patients after death from recurrent cancer. Ravitch and Sabiston indirectly condemned leaving the distal colon and rectum because of an experience with one patient who died of cancer of the rectum after previous preparation of the area by fulguration. However, in reviewing the history, there is no record of a proctoscopic examination from 1938 to 1945. Also at this operation the rectal stump was turned in and it is conceivable that polyps may have been buried and inaccessible to the proctoscope. Mayo and Wakefield recommended retrograde cautery through a sigmoid

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colostomy with subsequent closure of the colostomy. This would preclude future inspection of areas above the reach of the proctoscope.

To answer the question of how much terminal colon and rectum should be allowed to remain, one can leave a segment that is nearly equal to the length of the ordinary 20 cm. proctoscope, since no matter if one is fulgurating in the lower sigmoid or lower rectum, it is not possible to get any closer to the polyps than the length of the proctoscope itself. If proctoscopic examinations are done carefully and often repeated, polyps will not be overlooked. Helwig¹⁰ and others have pointed out that the overwhelming number of polyps showing malignancy are larger than .5 cm. in diameter and these can be visualized easily and destroyed.

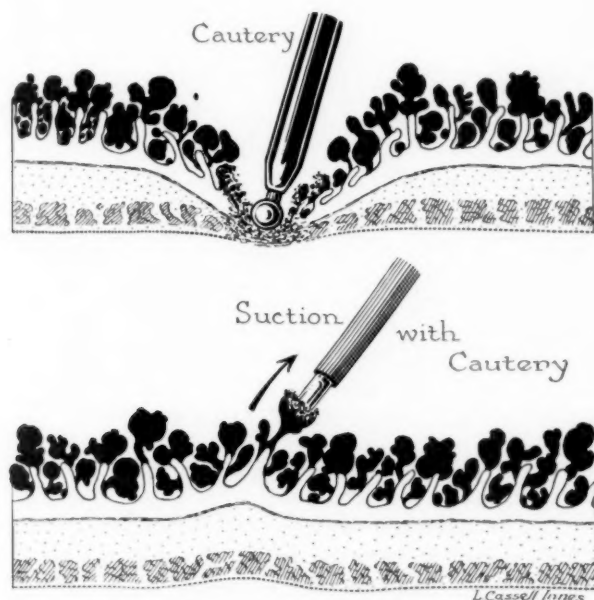


FIG. 1.—Upper sketch of conventional ball-point fulguration. Destruction may include adjacent mucosa and bowel wall as polyp is pushed about by electrode. Lower sketch shows destruction of polyp while it is held away from the bowel wall by the "suction cautery."

TECHNIC OF FULGURATON

I should like to describe a technic of fulguration of polyps that has several advantages over the usual methods. It will keep the field free from smoke, allow for accurate cautery, and prevent scarring and perforation. I use a long, hollow, metal bronchoscopic suction tube covered with rubber tubing except for one millimeter at the suction end. At the proximal curved end is attached the fulgurating current and the rubber suction tube. This idea was suggested to me by Dr. James Dresser, one of my former residents. It is a welcome improvement over the usual metal ball point held against the

polyps, which tends to roll out from under its pressure and inadvertently allows cauterization of the adjacent mucosa, and later, even perforation of the bowel wall itself may occur. In our suction-cautery method the smoke is automatically and instantly removed while fulguration is in progress, and one need not suffer the usual delay in introducing a separate hollow tube to remove the smoke. Secondly, and more important, with the hollow tip placed against the polyp, it will pick it up by suction and the polyp can be held away from the bowel wall while it is being fulgurated. Tiny polyps are sucked into the end of the tube and can be destroyed while under tension, so as to stretch the pedicle. We have found in using this method that even the most sessile-appearing tumor will have a demonstrable pedicle when stretched (as Helwig and others have shown). Microscopically, they reveal a central stalk with the tumor overhanging the margins like an umbrella. When large polyps are encountered, the suction tip can be placed against the neck of the polyp, the suction then turned on to fix the polyp at that point, and the cautery is immediate and quick in destroying the blood supply to the rest of the tumor.

Using this method of fulguration, as many as 300 polyps have been destroyed at one sitting. There was a temperature rise to 38° C the next day and several days of more frequent stools tinged with blood and mucus. Lack of adequate preoperative preparation of the distal colon by enemas is the only factor limiting the number of polyps that can be destroyed. Our patients do not experience the pain which accompanies the ball point method of cautery in which the polyp is pressed against the bowel wall, and in which fulguration often includes both polyp and bowel wall.

PREOPERATIVE PREPARATION

The preoperative preparation of the seven cases here reported consisted of restoration of the blood volume by whole blood transfusions, since these patients are invariably in a chronic state of secondary anemia. The bowel is prepared for an average of eight to ten days with 8 Gm. daily of phthalyl sulphathiazole (Sulphathalidine). Two days before the operation streptomycin in 2 Gm. amounts is dissolved in one quart of water and given in four one-glass doses daily. Vitamins, particularly B-complex, cevitamic acid, and vitamin K are given in large doses for 10 days. Forty-eight hours before operation two ounces of a 50 per cent solution of epsom salts are given to purge the colon thoroughly. An enema is given the night before the operation. During the ten days of preparation the patient is given a high protein, high carbohydrate, low residue diet supplemented by one or more liters daily of the Varco²⁸ high protein diet. Each patient comes to operation with a Miller-Abbott tube high in the jejunum.

The operative technic applied was the same in each case. Anesthesia used was a continuous fractional spinal of procaine occasionally augmented by pentothal sodium.

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TECHNIC OF OPERATION

Procedure: The abdomen is entered through a left paramedian incision with lateral retraction of the rectus muscle, and the incision is extended from the costal margin down to the level of the superior ramus of the pubis. After systematic exploration of the abdominal contents, the cecum and ascending colon are picked up, retracted medially, and the lateral reflection of the parietal peritoneum is divided, exposing the ovarian or testicular vessels and ureter below and the retroperitoneal duodenum above. The phrenocolic peritoneum is divided and the incision is continued along the gastrocolic ligament which is divided close to the colon. The phrenocolic attachments of the splenic flexure of the colon are then divided and the incision is carried down along the lateral gutter to the pelvic brim. The left colon is retracted medially, exposing the gonadal vessels and the left ureter in turn. The layer of peritoneum covering the mesentery of the mesocolon and ileum is then divided, beginning at the point about 15 cm. from the cecum at the edge of the ileum and continuing the entire length of the colon to the lower sigmoid. The peritoneum is wiped gently toward the root of the mesentery for 1 to 2 cm., exposing the vessels, for more accurate ligation and avoiding lumping up of the ligated and cut mesenteric edge. Leaving the bowel in continuity at the ileum and lower sigmoid while peritonealization of the lateral gutters is carried out gives ample time for the bowel to exhibit the limits of adequate circulation adjacent to the divided mesentery at the proposed sites of anastomosis. The opening into the lesser omental bursa is closed by suture of the transverse mesocolon to the cut edge of the gastrocolic ligament.

The ileum and lower sigmoid are then divided between clamps, using the actual cautery. If there is a great disparity between the size of the lumen of the ileum and that of the terminal pelvic colon or upper rectum, the ileum may be clamped obliquely to increase its diameter. The mesenteric borders of the ileum and sigmoid are denuded for a distance of one centimeter from the bowel clamp. The bowel ends are held in approximation with the mesenteries reversed. When there is disproportion between the sizes of the two lumens, the posterior row of sero-muscular sutures of 000 chromic are placed and held long without tying. Rubber-shod clamps are then placed a few centimeters from the anastomosis to prevent spillage. Kocher clamps are then removed and the row of sutures tied to be followed by a continuous mucosal suture which is continued anteriorly as an in-out-over Connell inversion suture. A second row of sero-muscular Lembert sutures are used to reinforce the anterior sutures, particularly at the angles. In spite of a turn-in of approximately .5 cm., a lumen considerably larger than an ileocecal valve is created. The mesentery of the ileum adjacent to the anastomosis is fixed to the posterior peritoneum over the promontory and bifurcation of the big vessels with several rows of interrupted sutures. This fixes the anastomosis and prevents any twisting. This is the most important step in creating an anastomosis that will function permanently in these patients. Five grams of sulfanilamide is dusted into the area of the sutures.

REPORT OF CASES

Case 1.—(159785). This 48-year-old white female, mother of eight children, was admitted to the surgical service of the Kern General Hospital on March 22, 1946. She stated that for 25 years she had had attacks of abdominal cramping, bloody stools, and diarrhea. Raw fruits and vegetables aggravated her condition. Recently, she was weak and short of breath. She had complete loss of rectal control since the birth of her first child 33 years before. (Her interesting family history originated with her grandfather, A. C., born in 1812, and noted in an old family bible as having "bloody bowels" for 20 years before he died in 1877. Seventy-six of his descendant and the incidence of polyposis is shown in the accompanying chart.)

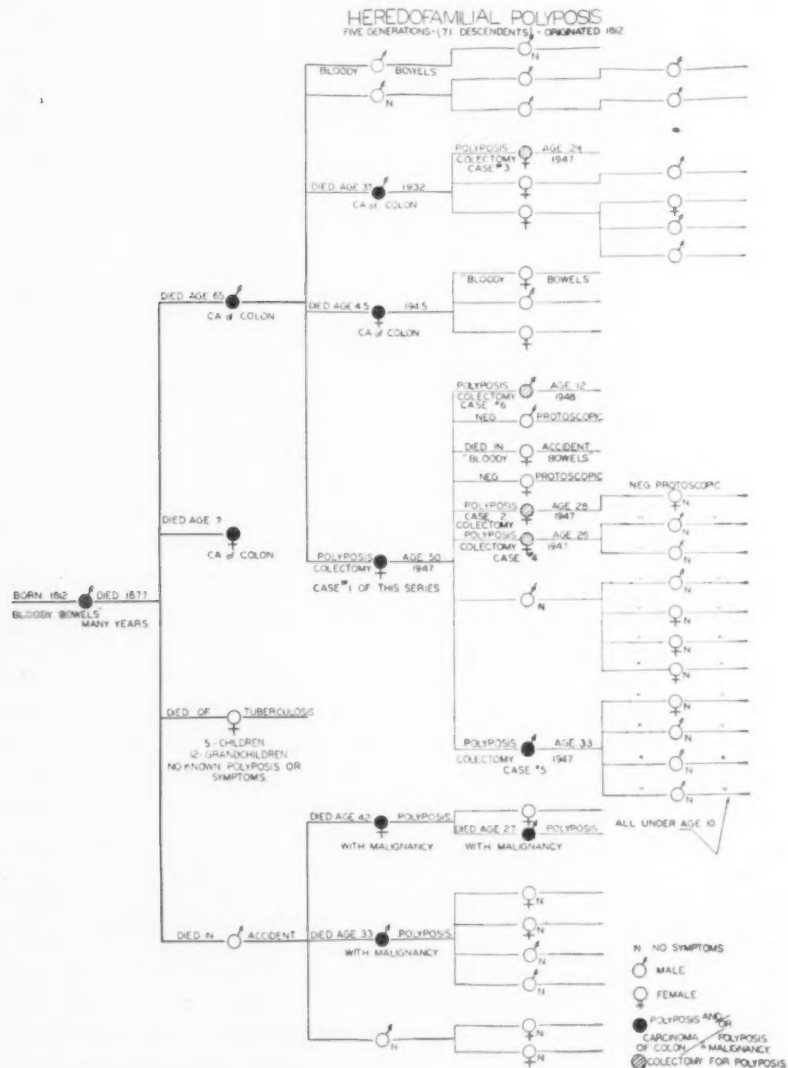


FIG. 2.—This is one of the longest family histories of polyposis ever traced (136 years). Approximately 40 per cent of the first four generations were afflicted with polyposis.

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Her physical condition was negative except for the incontinent anal sphincter and a complete relaxation of the perineum. On proctoscopic examination there were dozens of small polyps and two areas of larger "matted" sessile polyps. Biopsy of these suspicious areas was negative for carcinoma. Air contrast enema confirmed a polyposis involving the left colon with some question of the right half. Laboratory studies were within normal limits except for a mild anemia. Stools were positive for blood but negative for parasites and amebas. Preparatory to colectomy, on two admissions, a total of sixty rectal polyps were fulgurated. Since ileosigmoidostomy in the presence of an incontinent anal sphincter would have been intolerable, a sphincter plastic and perineorrhaphy was done at a subsequent admission. She obtained complete rectal control and in March, 1947, was admitted for total colectomy after the usual preparation. An end-to-end ileo-rectosigmoidostomy was carried out without difficulty. Postoperatively, her course was uneventful. The Miller-Abbott tube was removed on the third day and stools appeared on the fourth. She was up and about after her fourth postoperative day. Penicillin was administered for one week. She left the hospital on her tenth postoperative day having three bowel movements in 24 hours.

The pathologist's report described a specimen of 18 cm. of ileum, the appendix, the colon to the rectosigmoid, and the great omentum. There were 4200 polyps studding the entire colon mucosa. There was one large polyp at the mid-sigmoid. Numerous microscopic sections revealed a typical adenomatosis without evidence of cancer.

Subsequent course. The patient was admitted twice for cautery of the few remaining polyps in the rectum. The two large ones were cauterized and biopsied each time, and the second time a definite invasive cancer was found in the upper polyp. She was admitted then in January, 1948, for abdomino-perineal proctectomy and permanent ileostomy. Her postoperative course was normal, and at the end of four weeks she was fitted with a Koenig-Rutzen bag. She has been in excellent health and does not feel that her ileostomy is a great burden. The specimen removed consisted of a rectum and a few centimeters of sigmoid. There was a flat, polypoid tumor at 7 cm. and another at 16 cm. from the anus. Both showed adenocarcinoma. One had early invasion of the muscularis.

Comment on Case 1. This patient understood at the outset that she was not a good candidate for total colectomy with preservation of the rectum because of the two sessile polyps which were later proved cancerous. As is often the case, my original biopsy was not deep enough or I would have found the cancer earlier. However, this mother felt, and rightly so, that for her to be the first in the family to complete the operation with preservation of her rectum would have a good effect on the morale of her children and her nephew. This proved to be true, and they readily agreed to operation after her one-stage colectomy.

Case 2.—(151976). This 29-year-old female, mother of one child and daughter of the first patient, had attacks of bloody diarrhea for 12 years. On admission her hemoglobin was 6.3 Gm. and roentgenologic and proctoscopic examinations revealed a typical familial polyposis. The rectum and lower sigmoid were freed of polyps by the "suction cautery" method, after which on May 29, 1947, she had a one-stage total colectomy as previously described. The specimen contained thousands of polyps, none of which showed malignancy. She was discharged on her ninth postoperative day, and on subsequent examinations, her rectal segment was free from polyps and she had gained 15 pounds in weight.

Case 3.—(178060). This 24-year-old male, a nephew of the first patient, was well until two years before admission. He served in the Army, and at the time of discharge began to have bloody stools. He was admitted to a veterans' hospital, having lost 20

pounds in the previous 6 months. A diagnosis of polyposis with carcinoma in the transverse colon was made. Ileostomy and staged colectomy were advised. He refused this and left the hospital. In July, 1947, he was admitted to the surgical service of the Kern General Hospital. The diagnosis of polyposis with secondary anemia was confirmed, and because of the possibility of cancer, he was prepared for colectomy without preparation of the anastomotic site by previous fulguration of polyps. A procedure similar to the others was carried out. When the anastomosis was made, each polyp in that area was picked up with smooth forceps and a single ligature placed about the pedicle and tied without cutting off the polyp. A distance of 3 cm. was so treated before the anterior wall Connell suture was placed and the bowel closed. The patient did well until his fifth day, when he experienced severe unrelenting abdominal pain. Rather than risk a compromised circulation to any portion of the bowel, he was explored and only a moderate distention was found. While exploring the area of anastomosis it was inadvertently pulled apart for a few centimeters at the suture line. There was no alternative to re-establishing an anastomosis. This was done end-to-side after turning in the end of the colon. The patient developed a supra-pubic abscess 35 days after operation. This was drained and he left the hospital in good condition on his fifty-first day. The specimen was densely covered with approximately 5800 polyps from the tip of the cecum to the cut end of the sigmoid. Microscopic section revealed typical adenomatous polyps, some inflammation, but no cancer, either *in situ* or invasive.

Subsequent course. He gained 15 pounds in three months after operation. On successive admissions he had fulguration of 60, 300, 150, and 15 polyps. The stoma of the ileum could be seen emptying just above the rectosigmoid level. In all over 500 polyps were destroyed.

Comment on Case 3. Because of the ease with which polyps could be drawn away from the bowel wall by suction and then fulgurated, what formerly seemed to be a hopeless situation, requiring ileostomy and sacrifice of the rectum, gradually resolved itself into a segment of colon useful to the patient and free from the danger of cancer. The catastrophe on the fifth post-operative day is difficult to explain. The separation of the anastomosis at re-operation must be considered a surgical misadventure. The procedure did prolong his hospitalization and the 35-day delay in the appearance of the abscess is probably the result of attenuation of the infection by antibiotics and sulfonamides. The patient has now gained 50 pounds and will have his rectum examined for polyps every six months for the rest of his life.

Case 4.—(173234). This 25-year-old mother of two children and daughter of the first patient, had a history of cramping and bloody stools for several years. After preliminary destruction of the polyps in the rectum and lower sigmoid, she had a one-stage colectomy on October 21, 1947, with anastomosis of the ileum to the upper rectum, in the end-to-end reverse mesentery fashion with fixation of the adjacent ileomesentery to the posterior peritoneum. She was discharged on the ninth postoperative day having two stools in 24 hours. There was no cancer found in numerous sections taken from the largest of approximately 2500 polyps.

Case 5.—(182023). This 33-year-old male, father of five children and also son of the first patient, had a long history of abdominal pain and bloody diarrhea. Weakness and shortness of breath were the result of his chronic anemia (below 60 per cent hemoglobin). Extensive polyposis was demonstrated and after preparation on November 12, 1947, colectomy was carried out in identical fashion to the previous ones. He was discharged on his ninth postoperative day in excellent condition. Four of the 4000 polyps were larger than 4 cm. in diameter and 2 of these had cancer in the bulbous portion

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FIG. 3

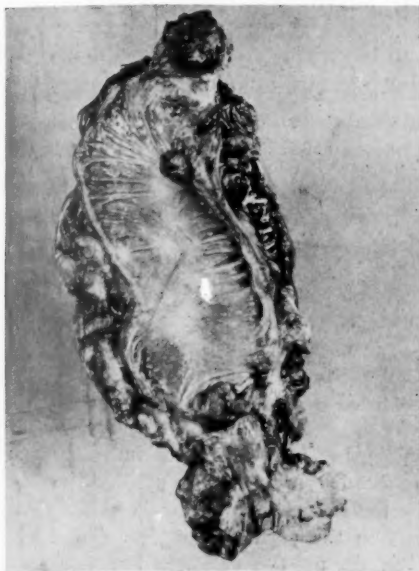


FIG. 4



FIG. 5

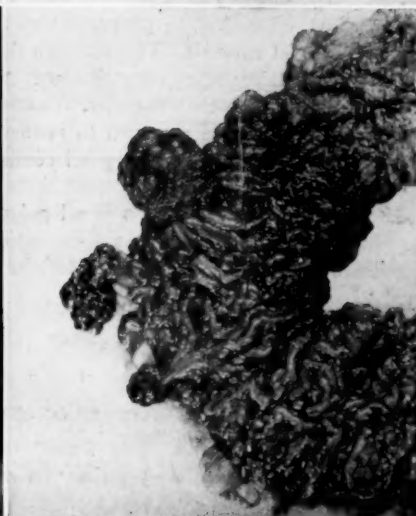


FIG. 6

FIG. 3.—Case 1. (Mother, age 48) Proctectomy one year after colectomy. Small early invasive carcinomas are shown in the lower rectum and adjacent to the rectosigmoid.

FIG. 4.—Case 2. Unusual number of large mulberry polyps. Largest is only a few centimeters from cecum.

FIG. 5.—Case 5. Film of air contrast enema showing large polyp at splenic and sigmoid areas.

FIG. 6.—Case 5. Microscopic evidence of carcinoma was found in light area of largest polyp.

without invasion of the stalk. It is interesting to note that one of the malignant polyps was found only 35 cm. from the tip of the cecum.

Comment on Cases 4 and 5. These two patients illustrate the fact that while polyps are found more commonly in the sigmoid, they are apt to be very infrequent in the rectum. This is a favorable circumstance when one considers the preparation necessary for an anastomosis and the necessity of keeping that area of the bowel free from polyps in the future. In these two cases it was necessary to destroy only 40, and 48 polyps respectively. Case 4 illustrates that fortunate patient who has large polyps with a fair amount of malignancy in the bulbous portion which has not yet invaded the pedicle.

Case 6.—This 12-year-old boy is the youngest son of this family. His health was excellent, and except for occasional blood in his stools he had no effects of polyposis. On proctoscopic examination only 8 small polyps were seen in the distal 25 cm. These were fulgurated. Air contrast enema suggested scattered polyps throughout the rest of the colon. A prophylactic colectomy was considered and finally requested by the family.

On April 14, 1949, a one-stage total colectomy similar to the previous cases was done. The day before operation the boy complained of very severe abdominal pain. This was thought to be a combination of fear plus the discomfort of the prophylactic intubation. A hypodermic of morphine was given by the resident to relieve the pain. At operation a small amount of free fluid was found in the peritoneal cavity. To our great surprise, on opening the lesser omental bursa during the colectomy, a typical acute pancreatitis was found. The pancreas was swollen and edematous, and there were numerous areas of fat necrosis. The common duct and gallbladder were normal to palpation. Serum amylase taken after operation was 388 units, 274 units the next day, and finally, dropping to normal by the third day. Temperature to 39°C and some intestinal distention persisted for 3 days and returned to normal on the fourth day. He was discharged on his twelfth postoperative day in good condition. His present health is excellent and he has only 2 stools in 24 hours.

The specimen contained 550 small polyps that could be counted easily, though many were pin-point sized. On microscopic section 3 of the polyps showed hyperchromatism and mitoses and were diagnosed as definite early cancer *in situ*.

Comment on Case 6. This elective prophylactic colectomy might have become a catastrophe because of the acute pancreatitis undiagnosed until operation. When the pancreas was exposed and the diagnosis apparent, it was decided to continue the colectomy since the blood supply to the right colon had been ligated. The cause of the pancreatitis was not determined. With no such previous situation to guide one, the decision to complete the colectomy and anastomosis was dictated by our being unable to turn back and by the fact that the patient was young and in excellent physical condition.

Case 7.—This patient was a 34-year-old white male admitted to the Santa Monica Hospital, Santa Monica, California, on June 20, 1948. He stated that he had an abdominal exploration in 1944 at which time his polyposis was so very extensive that nothing was done. The small bowel seemed to be involved also. His father and sister were both dead from carcinoma complicating polyposis. His present admission was because of a tender mass in the upper left quadrant of the abdomen. Roentgenographic study of the colon revealed a bowel literally bulging with polyps. In the left half of the transverse colon there was a filling defect compatible with cancer.

At operation June 1, 1948, the carcinoma of the transverse colon was found to be invading the stomach. A total colectomy, with resection of most of the greater curvature

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of the stomach, was done. The transverse mesocolon was carefully resected down to its attachments to remove all palpable nodes. The patient's postoperative course was uneventful and he left the hospital on his fifteenth day.

The specimen included the terminal ileum, the colon, a portion of the stomach and greater omentum, and 30 lymph nodes. In the colon alone there were 14,500 polyps. The terminal ileum contained numerous minute polyps, one millimeter or less in size. There was a large ulcerating carcinoma of the left transverse colon. On section this was an adenocarcinoma. The extension to the stomach was inflammatory only. None of the 30 nodes sectioned from the mesocolon were invaded by cancer. Several larger polyps showed typical early malignant change.



FIG. 7



FIG. 8

FIG. 7.—Colon in Case 7 literally bulging with polyps. Note area of constriction in left transverse colon. This is the adenocarcinoma shown in Figure 8.

FIG. 8.—Case No. 7. Adenocarcinoma in transverse colon. Mucosa of bowel covered by thousands of polyps.

Subsequent course. Previous to colectomy he had 300 polyps fulgurated elsewhere in ten visits. Using the "suction-cautery" method, 223 polyps were destroyed at one time without anesthesia. Approximately 100 polyps remain for future fulguration. He has gained 35 pounds in 4 months. He has four stools in 24 hours, but likely this will decrease after the rectal segment is completely free of the extensive polyposis.

COMMENT

The ages of the seven patients here described varied from 12 years to 48 years with an average of 29 years. A comparison of the number of polyps in the rectum and lower sigmoid to the number of polyps in the rest of the colon showed an average of 211 polyps in the lower segment compared to 4840 in the colon. The extremes in the rectum were from eight polyps in the 12-year-old child to 623 in patient No. 6. The extremes in the colon were

from a low count of 550 in the 12-year-old boy to 14,500 in the sixth case. Cancer was present in four of the seven patients. It was of the invasive type in only two of the four.

SUMMARY

1. The history of heredofamilial polyposis of the colon is reviewed both from its inheritable tendency and its pathologic aspects.
2. The history of the surgical treatment is reviewed. The disadvantages of staged removal of the colon are presented, and the advantages of one-stage total colectomy are emphasized.
3. A technic of "suction-cautery" of polyps in the distal 25 cm. of the colon and rectum is described. Minimal scarring, safety, and ease of destroying large numbers of polyps are the advantages. It is not necessary to remove the rectum and establish an ileostomy in familial polyposis unless cancer has appeared in the rectal or lower sigmoid segment.
4. Seven patients, six in one family, were subjected to one-stage total colectomy with end-to-end anastomosis of the ileum to the terminal pelvic colon or rectum without mortality. None has more than three stools in 24 hours. The rectal segments are free from polyps and will be inspected periodically for the duration of the patients' lives.
5. While the average follow-up on these patients averages two years, it is yet too early to determine the ultimate prognosis of these preserved rectums. The periodical inspection and destruction of subsequent polyps would seem to be the essential factor in preventing cancer in the future. Many more years of observation will prove whether or not this assumption is correct.

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DISRUPTION OF ABDOMINAL WOUNDS*

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THE INCISIONAL WOUND is the product and responsibility of the surgeon. It is the common denominator of all surgery and yet so numerous are the forces influencing optimal wound healing that even now the problem is incompletely understood.

The disruption of an abdominal incision is always a serious, and sometimes a catastrophic event, marring what might otherwise have been a brilliant surgical achievement. To prevent this unfortunate complication the surgeon must possess an intimate knowledge of the wound and its healing processes.^{1, 41, 45}

Many wound disruptions remain concealed beneath an intact cutaneous closure, go unrecognized, and later on manifest themselves in the form of a postoperative ventral hernia.^{14, 19} They are one of the common causes of this condition.²²

The present series consists of 45 cases of wound disruption occurring in a series of 1700 consecutive abdominal operations performed on the General Surgical Service during the interval from January 1, 1946 through February 28, 1949. For the most part this period corresponds to the newly instituted resident training program. The series is based on weekly reports of the senior surgical residents which contain records of all complications of all degrees of severity and is, therefore, rather complete. The inaccuracy of computing the frequency of wound disruption from hospital discharge files is notorious,^{21, 32, 44} and a major cause of discrepancy in the incidence of this postoperative accident as variously reported.

A wound disruption, or dehiscence, is considered to have occurred when the separation of any portion of a wound is demonstrated involving the anterior fascial sheath or deeper layers. Hernia repairs are not included among the abdominal operations,⁴ except for a small number of incisional hernias where the problem is akin to the closure of the ordinary laparotomy incision.

A survey of the literature discloses a remarkable tendency to draw conclusions regarding the frequency of various factors concerned in wound separation with complete disregard of the entire group of abdominal operations in which they occurred. It is obviously unjustifiable to state, for example, that one type of incision disrupts more frequently than another unless the total number of times each one was used is known. In order more fairly to evaluate certain systemic and local factors in the healing of the wound, the

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operative notes on all laparotomies performed on the general surgical service over the period in question were personally reviewed where available (over 98 per cent of cases). Wherever indicated the findings have been subjected to statistical analysis for reliability. Where the numbers are too small to stand this test of significance much can be gleaned from an analysis of certain individual cases. In going through the clinical charts of the cases with disruption it very quickly became apparent that only by a very careful review of the record, often supplemented by questioning the ward surgeons and patients themselves when available, could all of the many factors potentially contributing to the disruption be evaluated. Not infrequently the nurses' notes would provide some valuable clue that otherwise might not have been mentioned.

At this point it can safely be said that there is no single factor responsible for wound disruptions in all cases, and that in any particular case it is frequently necessary to indict a combination of agencies rather than any single one. For excellent treatments of the subject I would refer to the collective review by Hartzell and Winfield¹⁹ in 1939, and a symposium on the subject published in the *ANNALS OF SURGERY* in 1934. It is surprising how little of moment has been added to the subject since.

Incidence. The incidence of wound disruption as reported in the literature varies from 0.3,³⁵ to 3 per cent.^{19, 39} For a variety of reasons, most estimates are too low.^{19, 32, 39} The incidence in this series is 2.6 per cent.

Age. It has long been recognized that wound disruptions occur with greater frequency in the upper age groups,^{32, 48} although some regard age, in itself, as of little consequence.^{14, 19} The collective review reports an average age of 44 years.¹⁹ The average age in our series was 50 years, as opposed to an average age for all patients undergoing laparotomy of 38 years. But this does not tell the whole story. The population of a hospital and of those undergoing operation is not a normal population in its age distribution, and this is particularly true of a Veterans Hospital. Therefore, the ages of all patients undergoing laparotomy were recorded graphically in groups of five years (see Fig. 1). It is quite obvious that one has here two natural subgroupings, those 45 or over, and those below; and that these two groups lend themselves readily to comparison.

In the younger group there were 14 disruptions among 1115 operations, or 1.3 per cent, and in the older group there were 31 instances among 585 operations, or 5.4 per cent, over four times as many. This difference is statically significant.* Thus, age apparently is of considerable import, but the interpretation of its influence requires further investigation, with consideration of such factors as the healing rate of the tissues, the presence or absence of cancer, the vitamin C content of the tissues,⁵⁰ to name but a few examples known to vary with age.

Sex. Although individual reports differ, the literature appears to show a higher incidence of disruptions in males than in females,^{10, 17, 32} roughly in a

* $\chi^2 = 24.35$. The chances that this is a sampling error are 6 in 1,000,000.

ratio of 2 to 1.^{19, 39} Since the figures on the total number of laparotomies done on each are rarely supplied, the validity of this observation is open to question. In our series, no disruptions occurred in female patients but, as there were only 72 laparotomies performed in this group, the number is too small to use.

Race. Only a few analyses are available regarding race in relation to wound separation.¹⁹ In this series there was only one disruption in a colored patient, the remaining 44 being white. 10.8 per cent of all operations were performed in Negroes, and this corresponds roughly to the Negro fraction of the population in this city. Thus the disruption rate in whites was 2.9 per cent and in Negroes 0.54 per cent. This difference is slightly significant.*

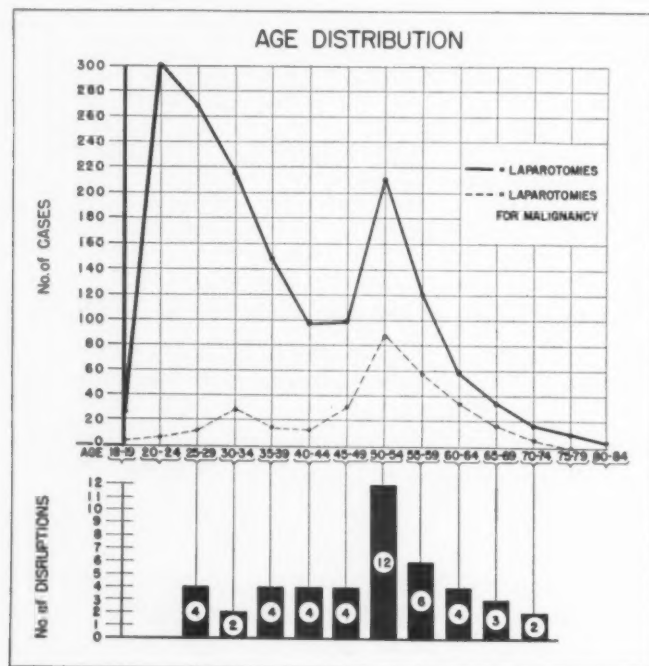


FIG. 1.—Graphic representation of age distribution in groups of five years. Solid line represents all laparotomies. Broken line signifies laparotomies for cancer. Solid blocks below denote the number of disruption cases in each age group. The break, above and below 45 years, (corresponding to the two wars) is quite apparent.

Season of the Year. Occasional reports^{14, 19, 39} have suggested a seasonal variation in the disruption rate, for which respiratory infections and dietary factors have been held responsible. This series shows no marked variation, 11 cases occurring in the spring, 9 in the summer, 11 in the fall and 14 in the winter.

* $\text{Chi}^2 = 3.4470$. The chances that this is a sampling error are 6 in 100.

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Systemic Factors. There are several systemic or constitutional factors which bear upon the rapidity and strength of wound healing. *Cancer* has commonly been accused of predisposing to dehiscence.^{10, 17, 19, 40} In the collective review by Hartzell and Winfield, 22 per cent of the disruptions occurred where there was cancer present; in this series 38 per cent. What is more revealing, however, is the fact that in the present series, of all cases of cancer, subjected to laparotomy 5.1 per cent were complicated by disruption, whereas among the benign conditions only 2.0 per cent had this complication. This difference is significant.* But the significance of the mathematical difference indicates only a correlation and not a cause and effect relationship. Is this increased rate of disruption a result of cancer *per se* or is it a reflection of age, debility, a high degree of hypoproteinemia,^{2, 20} and other such influences? This problem is easily attacked from one angle by considering the two age groups previously mentioned (see Fig. 1). We find here 85 cases of cancer in patients under 45 years of age subjected to surgery with only one disruption for an incidence of 1.2 per cent, and 240 in the older group with 16 disruptions, or 6.7 per cent (see Table I). Although the numbers are rather small and only one factor is compared, it seems a fairly valid inference that cancer *by itself* does not predispose to wound disruption.

TABLE I.—*Disruption in Relation to Age and to Cancer.*

	Disruption Rate	
	Under 45 Years	45 Years or Over
All cases.....	1.3% (14/1115)	5.4% (31/585)
Cancer cases.....	1.2% (1/85)	6.7% (16/240)
Benign cases.....	1.3% (13/1030)	4.3% (15/345)

Anemia has sometimes been blamed.¹⁹ Estimations of the hemoglobin and/or red blood cell levels in the ante-operative and early postoperative period were recorded in most of the cases of disruption. Using 11.5 Gm. per 100 cc. of hemoglobin as an arbitrary critical level, only three cases showed an appreciable anemia. Since all three of these also had an associated hypoproteinemia as well, anemia *per se* does not appear to be a significant factor in this series.

The importance of adequate stores of *protein* in the body, as indicated by the serum protein level,¹³ in the proper healing of wounds has been amply demonstrated by many investigators.^{20, 43} Although serum protein levels without knowledge of the total circulating blood volume are somewhat misleading they may give some indication of a general trend. In this series there were 35 instances among the disruptions where serum protein determinations are recorded. Using 6.5 Gm. per 100 cc. of blood as an arbitrary critical level it was discovered that 20 cases had low figures in the early postoperative period and two cases had low preoperative levels but were not measured again postoperatively. If we do not consider the five cases occurring before the fourth

* $\text{Chi}^2 = 9.6608$. The chances that this is a sampling error are less than 2 in 1,000.

postoperative day (which is the earliest that wound strength can begin to increase) we find, nevertheless, that at least 19 out of 32 cases, or 62 per cent, had low serum protein levels. Moreover, if it were possible to make corrections for dehydration, which tends to exaggerate the values, and if the six cases with preoperative values above 6.5 and without postoperative determinations had been completely studied, the percentage might be even higher. Therefore, hypoproteinemia is probably a rather significant influence.

Although adequate quantities of *vitamin C* must be present in order to assure proper wound healing,⁴⁹ the presence of a deficiency in a surgical patient is difficult to estimate and evaluate.^{8, 26, 28, 30} The records of the disruption cases were analyzed on the arbitrary assumption that a patient who received at least 300 mg. of vitamin C daily by the parenteral route for several days postoperatively should not be appreciably wanting.⁵ Of the 45 patients, 39 received adequate amounts of vitamin by this standard, four were inadequate (but were not necessarily deficient), and two were indeterminate. Most patients received the vitamin preoperatively and many in amounts exceeding those mentioned. From these observations it would not appear, therefore, that vitamin C deficiency here played a significant role in the dehiscences,³⁰ unless vitamin C requirements in surgical patients by the customary routes of administration⁸ are considerably in excess of those commonly believed to be necessary.²⁴

Catgut sensitivity. Failure to find catgut sutures in early wound separations led to speculation and experimental work, supporting the possibility that a hypersensitivity to catgut sutures might lead to early digestion and dissolution in the tissues.^{22, 27} Of 43 disruptions occurring over 24 hours postoperatively 38 were closed in layers, eight of which had chromic catgut and two, chromic catgut and cotton in separate layers. Considering all the abdominal operations closed in layers, disruption occurred in 1.3 per cent of catgut wounds (eight out of 594), 3.1 per cent of wounds closed with non-absorbable material (28 out of 907), and in 3.5 per cent (two out of 57) of instances where both were used. Since cotton or silk, and catgut were used with about equal frequency in McBurney incisions the frequency of this strong wound does not influence the above figures (Table II). It appears, therefore, that the use of absorbable suture material *per se* did not predispose to wound separation in this series.

Incision. The type and location of the abdominal incision has generally been regarded as an important factor in wound disruption, although there are a few dissenting voices.^{22, 40} It is usually claimed that vertical incisions are more prone to disrupt than transverse or oblique ones,^{7, 32, 36} upper abdominal more frequently than lower abdominal,^{7, 10, 14, 18, 47} muscle splitting more often than muscle retracting,^{31, 40} and so forth, but it is surprising how many of these conclusions are based merely on the total number of disruptions occurring for each particular type of incision without regard for the frequency of its use. The wounds here were classified into various types (see Fig. 2) and

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then Table II was constructed, giving the number of times each incision was used and the number of disruptions for each.

Table III compares the incidence of disruption among the various groupings of incisions. The differences are not marked and will not stand the test of statistical significance.

TABLE II.—*Frequency of Incisions.*

Incision	Laparotomies	Disruptions	Viscus in Wound*
Upper midline	37	1	0
Upper right rectus splitting	178	10	12/0
Upper right paramedian	24	1	0
Upper left rectus splitting	168	8	17/0
Upper left paramedian	45	1	1/0
Lower midline	11	1	1/1
Lower right rectus splitting	64	1	5/0
Lower right paramedian	28	0	3/0
Lower left rectus splitting	44	5	18/3
Lower left paramedian	83	6	23/2
Right paraumbilical	26	1	2/0
Left paraumbilical	1	0	0
Kammerer or Battle	32	0	1/0
Upper transverse	129	6	10/1
Upper right hemitransverse	32	0	6/0
Upper left hemitransverse	17	0	5/0
Lower transverse	11	0	0
Lower right hemitransverse	13	0	1/0
Lower left hemitransverse	6	0	3/0
Upper right oblique	80	2	1/0
Upper left oblique	7	0	1/0
Lower obliques (classed with hemitransverse here)			
McBurney (classical)	473**	1	25/0
McBurney (transverse)	151	0	0
Thoracoabdominal	(11)†	1	1/1
Miscellaneous	10	0	0
Not known	40	0	2/0
Totals	1710‡	45	138/8

* Upper left figure indicates total number of colostomies, gastrostomies, etc. Lower right figure indicates the number in disrupted wounds.

** Includes 3 on left side.

† Included under appropriate abdominal component.

‡ Some patients had more than one incision.

Since, on anatomic grounds, transverse incisions appear to possess certain advantages over vertical ones,³⁶ it was thought that a brief analysis of the six upper transverse incisions disrupting might prove revealing:

Two cases (Nos. 24, 35) occurred on the operating table after the skin had been closed during bronchoscopic or endotracheal suctioning. Immediate re-closure showed that all the silk sutures in the anterior fascial layer were broken in one case, and those throughout the entire wound in the other.

One case (No. 5) had its onset on the day of operation when the patient became distended and vomited up a blocked Levine tube. Here too, all the silk sutures were broken.

One case (No. 31), in which the transverse incision was closed by means of through-and-through sutures alone, was discovered on the fifth postoperative day after an episode of severe coughing and vomiting. A loop of small intestine had worked its way out between two sutures which were probably placed a little too far apart. The early date of occurrence here makes the mechanical stress factor probably more important than retarded healing.

One case (No. 36), closed with interrupted chromic catgut in layers plus heavy braided silk retention sutures, disrupted on the sixth postoperative day when the patient

TABLE III.—*Disruption Rates by Types of Incisions.*

Type of Incision	Total	Disruption	Rate
Upper vertical.....	452	21 (0)	4.6%
Lower vertical.....	262	13 (6)	5.0%
() Indicate the number containing a viscus in wound.			
Vertical.....	746*	35 (6)	4.7%
Transverse and oblique.....	297	9 (2)	3.0%
* Includes paraumbilical incisions and some miscellaneous.			
Upper right vertical.....	202	11	5.4%
Upper left vertical.....	213	8	3.8%
Lower right vertical.....	92	1 (0)	1.1%
Lower left vertical.....	127	11 (5)	8.7%
Upper paramedian.....	69	2	2.9%
Upper rectus splitting.....	346	18	5.2%
Lower paramedian.....	111	6 (2)	5.4%
Lower rectus splitting.....	108	6 (3)	5.6%
McBurney.....	624	1	0.16%

coughed and choked as a nasogastric tube was being passed for diagnostic purposes, stating that "I felt as if my intestines came out." The appearance of copious sero-sanguinous drainage and the passing of a clamp into the peritoneal cavity a few days later confirmed the diagnosis. Operative repair was not required.

One case (No. 22) occurred on the twelfth postoperative day in a debilitated patient on whom a radical pancreaticoduodenectomy had been performed and whose wound, closed in layers with cotton, contained a colostomy loop and drains allowing the escape of biliary and pancreatic secretions through it. There were no significant mechanical factors present here and poor healing, infection, a viscus in the wound and drainage of digestive enzymes seem to be the important items.

In summary, the presence of strong mechanical disrupting forces in five of the six cases indicates that not even transverse incisions will protect the

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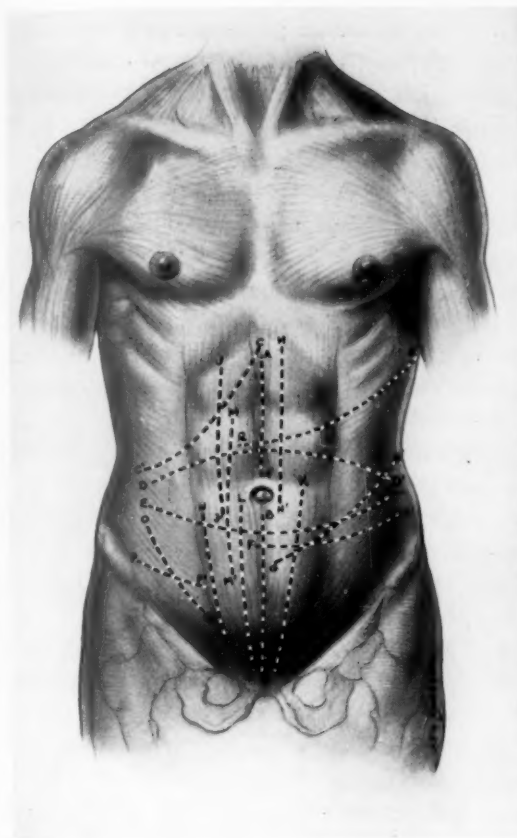


FIG. 2

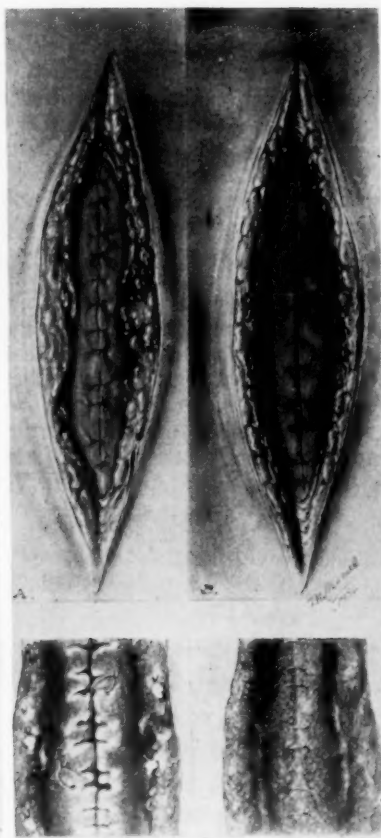


FIG. 3

FIG. 2.—Classification of abdominal incisions into types and abbreviations for each used. A-A': upper midline (UM). B-B': lower midline (LM). C-C': upper right oblique (URO*). D-D': upper transverse (UT). E-E': lower transverse (LT). F-F': lower left hemitransverse (LLT*). G-G': lower left oblique (LLO*). H-H': upper left paramedian (rectus retracting) (ULP*). J-J': upper right rectus splitting (URR*). K-K': lower left rectus splitting (LLR*). L-L': lower right paramedian (LRP*). M-M': right para-umbilical (RPU*). N-N': Kammerer or Battle (K). O-O' and P-P': McBurney and transverse-type McBurney muscle splitting, respectively (Mc and Mc). R-R': thoraco-abdominal (TA).

FIG. 3.—Stevenson and Reid show the effect of tissue strangulation on wound healing. A and B are rectus incisions made under identical conditions on a dog. In A the fascial sutures were tightly drawn and large tags of tissue were ligated. In B the tissues were handled gently, bleeding was controlled without ligatures and the fascial sutures were made just tight enough to approximate the edges.

A' and B' show the same wounds opened for inspection five days later. Neither was infected but in A' the sutures had produced necrosis and cut through the fascia and tags of slough distal to the ligatures are seen. B' showed smooth granulation tissue over its entire surface. B' has far greater resistance to infection than A'. (*Am. J. Surg.*, 46: 442, 1939. Reprinted with the permission of the American Journal of Surgery.)

* Similarly designated for other quadrants or opposite side.

patient when the stress factor is great enough. Moreover, since increased intra-abdominal pressure is probably exerted equally in all directions, as in any hydrostatic system, this force may be of greater moment than that of muscular pull, wherein lies the presumed superiority of transversely placed incisions.

The single McBurney wound disruption occurred after operation without drainage for acute suppurative appendicitis and localized peritonitis in a poorly nourished 53-year-old white male with severe chronic bronchitis and asthma of many years' duration.

Closure of the Wound. Considerable information is available in the literature regarding recommended technics of wound closure.^{17, 23, 47} The subject can only be touched upon here but the superlative chapter by Stevenson and Reid⁴¹ is to be highly recommended.

Prompt wound healing is facilitated by a minimum of necrotic residue, bacterial contamination and foreign material.⁴⁵ This is accomplished by gentle handling of the tissues, adequate hemostasis, the use of fine suture material, needles and instruments, and the protection of wound edges from contamination and dehydration during the operative procedure.⁴⁶ Ligatures should encircle only the bleeding vessel wherever possible.

Probably the most common error in technic that is committed comes from tying sutures too tightly,^{41, 45, 47} thus devascularizing the approximated edges of the very structures we depend upon for healing (see Fig. No. 3). The purpose of sutures is merely to maintain the wound edges in apposition until natural healing processes take over. Using suture material heavier than the minimal required to accomplish this end serves only to encourage strangulation of tissue and to introduce unnecessary foreign material into the wound. Studies of wound healing show that with minimal trauma and under optimal conditions a wound does not begin to gain in tensile strength until the fourth or fifth postoperative day.⁴⁵ Tissue necrosis caused by sutures that are too tightly tied prolongs this lag phase of wound healing and at the same time allows the wound edges to separate when the sutures become slack as a result of cutting through the tissues (see Fig. 3).

Anatomic dissections of the abdominal wall, unless serving some specific purpose, are also to be condemned, since they tend to deprive the fascial layers of their blood supply.

Irrigation of the wound during closure tends to remove tiny bits of detached tissue, which favor bacterial growth and inhibit wound healing if allowed to remain.

The relative merits of absorbable and non-absorbable suture material⁶ cannot be discussed here, but it is probably a truism that the technic of usage is more important than the material itself, and that utilization of fine silk or its equivalent imposes upon the surgeon certain refinements of method that encourage sound wound healing. Mixing both types of suture in the same wound layer is probably a bad practice.⁴⁷

There are many fine points in the method of wound closure that the observant surgeon learns by experience. The most important single step in

closure of the wound is exact approximation of the peritoneal layer.^{7, 16, 21} A stitch which everts the peritoneal edges not only prevents adhesions but favors early sealing of the inner surface of the wound. There is considerable support for Freeman's theory¹⁶ that wound disruptions start with a tiny wedge of omentum or bowel finding its way through a small peritoneal defect. A continuous stitch, if pulled too tightly, devascularizes the joined edges; if slack anywhere, it threatens the integrity of the whole line of approximation. For these and other reasons, interrupted sutures, although taking longer to insert, are considered preferable.^{4, 9, 33} If a continuous suture is used it should be supported by interrupted stitches at reasonable intervals. Moreover, when the peritoneal layer is being closed, it is not difficult to neglect to include the transversalis fascia in the bite; this is a serious omission, depriving the layer of much additional strength.³¹ A too-frequent cause of unsatisfactory closure of the peritoneal layer results from imperfect relaxation of the abdominal wall at the time. For avoidance of this the assistance of a skilled anesthetist is most desirable. Here is one stage where transverse and oblique incisions offer a distinct advantage, since the wound edges can be brought closer together by breaking the operating table and flexing the patient; perhaps this accounts partly for the superior results with their use reported by some. Mattress sutures usually tend to cut through the tissues less readily than interrupted ones, and if mattress sutures are placed first, for the length of the wound, and then drawn up simultaneously prior to tying, closure of an otherwise difficult incision may be accomplished without tearing the peritoneal layer.

Any extraneous structure placed in the incision will threaten its integrity. If the object is a small Penrose drain or catheter, the danger is not significant¹⁷ unless, of course, infected material or powerful digestive enzymes are introduced into the wound by this route. This attitude is supported by the fact that although drains were brought out *through the wound* in at least 169 cases this appeared to be an important feature in one, and possibly two, of the three disruption cases in this group; in those two instances, however, it was a regrettable procedure, since it contributed directly to the complication. Bringing a viscus out through the incisional wound, on the other hand, appears to be a dangerous practice, for placement of a colostomy, gastrostomy, ileostomy or cecostomy in a wound was performed in 138 instances and eight of these cases appear in the disruption group (see Table II).

Whether or not the use of "retention," "tension" or "stay" sutures will prevent wound disruption has been a bone of contention among surgeons for decades, and cannot be solved by this study. Whipple and Elliott,⁴⁷ Meleney and Howes³² and others believe they predispose to infection and advise against their use. For an excellent discussion of the mechanical forces relating to the use of sutures the article by Price³⁵ is recommended; retention sutures as customarily used, are here disapproved. It appears, however, that closure in layers plus through-and-through stay sutures, preferably of wire, as recommended by Holman and Eckel²³ (see Fig. 4), confers a certain additional measure of protection as reported by these reliable observers. The added effort,

time and risk associated with their use¹² may be justified in certain selected cases, but the prescribed technic should be adhered to closely to minimize these factors. If they do not prevent wound dehiscence, retention sutures protect against evisceration. Under any circumstances they should never be tied so

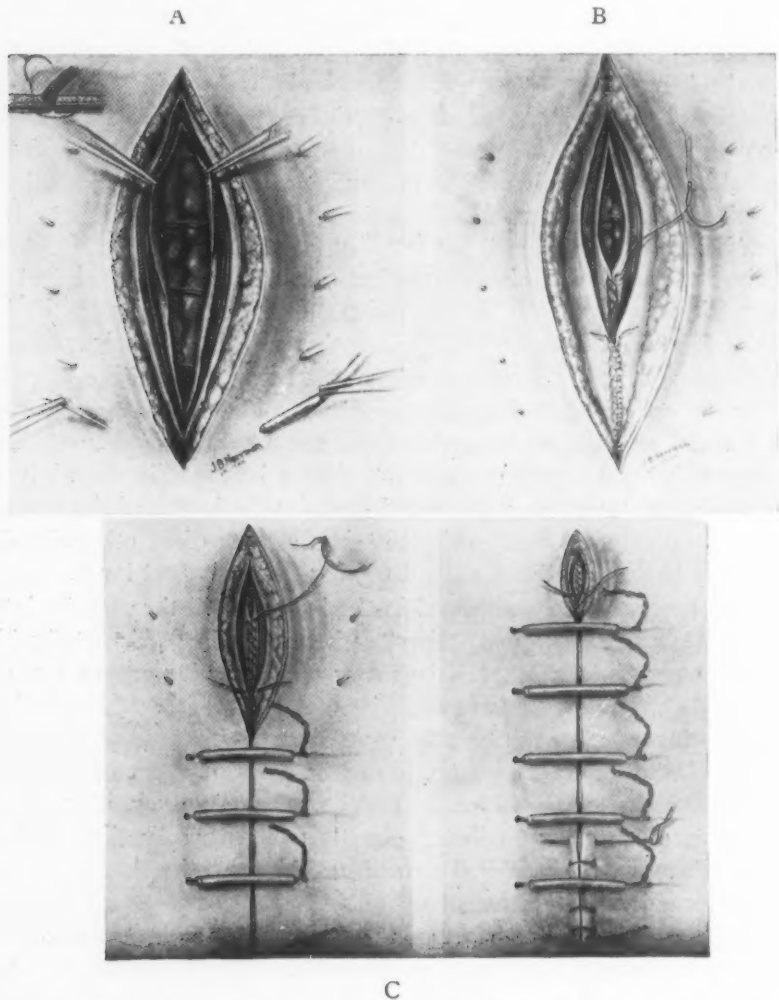


FIG. 4.—Holman and Eckel's method of using retention or stay sutures. For details of the technic the original paper should be consulted. (*Surg., Gynec. & Obst.*, 72: 1052, 1941. Reprinted with the permission of Surgery, Gynecology and Obstetrics.)

tightly that a finger cannot be inserted easily between them and the skin. Buried retention sutures, particularly those of the near-and-far variety, distribute the strain more evenly and appear to possess certain virtues where layer closure is not preferred. It has been the author's personal impression that by inserting slightly heavier sutures, or two or three closely spaced fine ones, at

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certain natural strongpoints in the incision, as much additional support is gained as through the use of retention sutures, and the rule that a suture should not be of more than twice the tensile strength of the tissues is not broken. In the transverse incision these key points are the linea alba and the lateral margins of the rectus sheath; in the vertical incisions they are the tendinous inscriptions which, unfortunately, are usually lacking in the lower abdomen (see Fig. 5).

In this series retention sutures were utilized in the closure of the abdominal wound in at least 280 of 1710 incisions; 233 were through all layers including the peritoneum and 47 were superficial to this. Through-and-through sutures alone were used in 49 cases, of which 25 were of the near-and-far variety. Among the disruption cases there were 11 instances in which retention sutures had been used giving an overall disruption incidence of 3.2 per cent. Of the 11, seven were through-and-through all layers plus a layer by layer closure, two superficial to the peritoneum plus a layer closure, one straight through-and-through sutures alone, and one through-and-through sutures of the near-and-far variety. An examination of these 11 cases is of some interest:

In two cases (Nos. 8, 45) the retention sutures were removed on the eighth and ninth postoperative days respectively—probably too early.^{23, 48} One had grossly infected suture tracts. Operative closure was required in both.

In two cases (Nos. 7, 39) the retention sutures broke. One had heavy braided silk, the other heavy steel wire, both in addition to a layer by layer closure. Both accidents happened during bouts of forceful coughing or vomiting. In one the suture tracts were infected. Both were treated by re-operation.

In one case (No. 31), already mentioned among the transverse incisions, the through-and-through sutures were probably placed a little too far apart. A similar situation arose in one of the cases (No. 7) where the disruption was closed by means of through-and-through wire sutures and two days later there was again profuse sero-sanguinous drainage from the wound; at re-operation a deep separation was found with bowel in the depths of the wound. This was the only instance in which this unfortunate development occurred.

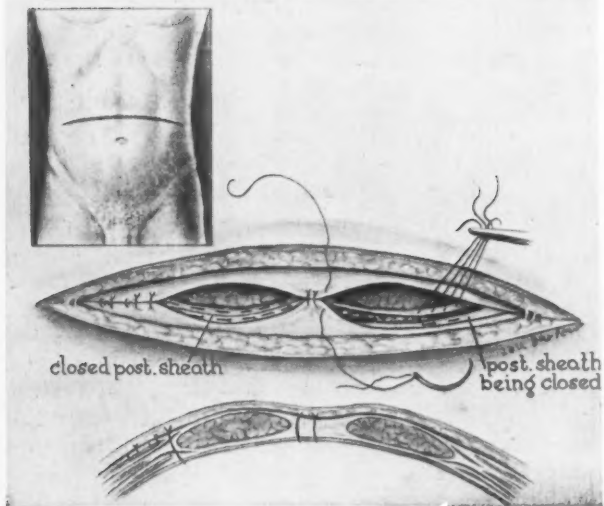
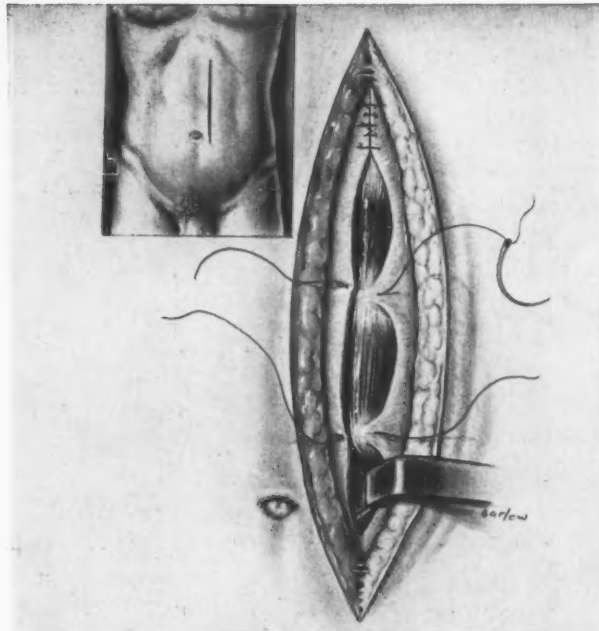
In three instances (Nos. 12, 41, 42) the separation appeared to be confined to the anterior sheath and no operative treatment was required. In one instance the suture tract was infected, in one there was a hematoma and probably low grade infection, and in one the wound itself was infected in part.

In two instances (Nos. 29, 36) disruption through all layers was manifested by profuse sero-sanguinous discharge from the wound and confirmed by passing a clamp into the peritoneal cavity. Both were treated conservatively with early good results. Both now have incisional hernias.

In one instance (No. 16) removal of near-and-far through-and-through sutures placed 1 cm. apart on the twelfth postoperative day revealed loops of bowel glued to the wound edges. The patient had peritonitis and the wound was probably infected. He was considered too ill for surgery and subsequently died.

When the retention sutures are placed superficial to the peritoneal layer they depend entirely on the anterior fascial sheath for their real holding powers. For this purpose they have several disadvantages and no advantages as compared to the "far-and-near" variety of suture for this layer recommended by Whipple and Elliott.⁴⁷

A



B

FIG. 5.—(A and B) Drawings illustrating a method of reinforcing an upper paramedian or transverse incision respectively, by means of slightly heavier or more closely spaced fine sutures at natural strong points, without breaking the rule of not having the sutures more than twice the tensile strength of the tissues supported.

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Time of Occurrence. The postoperative day upon which a wound separation is found is not always the day upon which it starts or occurs. Most disruptions are concealed in the deeper layers of the wound and do not manifest themselves until after the skin sutures are removed, which probably accounts for the fact that in the literature the eighth postoperative day is found to be the average time for disruption to occur.^{19, 39} From the standpoint of the causative factors alone it is rather important to know just when a dehiscence had its onset,⁴² for one starting before the fourth or fifth day, when the wound has not yet had time to develop an increase in tensile strength, is obviously not primarily a result of poor wound healing. The holding powers of the tissues may, however, be at fault. Sometimes the patient will volunteer the information, more frequently interrogation will elicit it, that he felt something "give" or "bust" in the wound, usually during a fit of coughing or vomiting. Not long thereafter profuse sero-sanguinous discharge generally occurs, and this is practically a pathognomonic sign of disruption. There was profuse sero-sanguinous discharge mentioned in 22 and smaller amounts in five of the 43 cases of disruption occurring after return from the operating room. It was not mentioned in 16 instances, but probably occurred without notation or was overshadowed by more dramatic events in several of these. It is a most important warning sign. Following the initial episode the patient may complain of pain in his wound, vomit, and begin to show signs of distention and ileus which are frequently later on mistakenly regarded as causes rather than results of the separation. At secondary operation it is not at all uncommon to discover indications that the disruption has been present for several days.

In this series the disruptions were detected from the time before the patient left the operating theater (two cases) to the twelfth postoperative day, with the average (and median) being the seventh postoperative day. In 12 cases, however, careful review of the record disclosed that the disruptions had their onset one to seven days earlier.³¹ A few case abstracts will demonstrate this point:

Case 39.—A large, heavy 42-year-old white male had a duodenal diverticulum removed through a long upper right rectus-splitting incision. He was closed with interrupted double-zero silk sutures in layers plus several through-and-through retention sutures of No. 3 braided silk. A Penrose drain was inserted through a right upper quadrant stab wound. Wound separation and evisceration were discovered on the tenth postoperative day, after large amounts of pink fluid were found draining from the wound. Review of the chart showed that on the seventh day he had felt something "give" in his wound during a coughing spell induced by passage of a Levine tube. At that time he snapped two of his retention sutures. The Levine tube was being passed because of distention and incomplete ileus which had begun on the third postoperative day. This ileus, it was detected, began not long after a previous episode of profuse sero-sanguinous drainage on the dressing presumed, at that time, to have come from the stab wound drain, since the incisional wound was outwardly intact. The cause of this first episode was discovered from the nurses' notes: during the night of the second postoperative day there had been several short periods of forceful vomiting. At the time of operative repair, the disruption was obviously several days old and the silk sutures were intact but had produced a "postage stamp" type tear through the tissues.

Case 38.—An ileotransverse colostomy was performed on a well-nourished 54-year-old colored male with actinomycosis, and the lower left paramedian incision was closed in layers without drainage using interrupted mattress sutures of No. 0 chromic catgut. Wound separation and evisceration were discovered by the nurse on the eighth postoperative day. The wound had previously been examined on the sixth and seventh postoperative days because of small amounts of pink discharge. At operative repair the process was obviously several days old. Questioning the patient revealed that on the evening of the third postoperative day he had felt something give way in his wound during a bout of vomiting and had reported this fact to the doctor on call at the time.

Case 3.—An anterior resection of the sigmoid for carcinoma had just been performed on a 52-year-old white male and the wound closed in layers with interrupted mattress sutures of fine (No. 34) stainless steel wire. The subcutaneous tissues were packed open and the dressing was in place when the anesthesiologist began aspirating secretions from the tracheo-bronchial tree. This caused the patient, who was rather light, to rear up on the table to a 45° angle several times. The surgeon had his hand over the dressing at the time and thought he felt something give. Inspection of the wound then and on the first postoperative day disclosed it to be superficially intact, but on the third postoperative day there was profuse sero-sanguinous drainage from the wound and disruption with evisceration was found on dressing it. At operative repair all the sutures had torn through the tissues except for one which was broken. The fact that the skin was not sutured probably hastened the detection of this separation.

Pathology of the Disrupted Wound. A careful description of the disrupted wound at the time of secondary operation is of great value in estimating the significance of the various factors concerned in its separation. The extent of dehiscence of the various layers, their appearance, whether the suture material has been digested, broken or torn through the tissues, whether knots have become untied and so forth, are observations of great importance. A biopsy of the wound edge may prove revealing and provide information concerning the degree and type of healing. The influence of infection in the disrupted wound is difficult to evaluate.³⁸ In this series there were only a small number in which gross infection appeared to be present but, as Meleney³² and Harvey²¹ have pointed out, only routine culturing of all cases will demonstrate how frequently a low grade infection actually exists. Unfortunately cultures were not taken sufficiently often in our group to allow discussion of this point.

Of the 45 disruptions, 39 were complete, *i.e.*, extended through all layers of the abdominal wall, and six involved only the anterior sheath as far as could be detected. Although most disruptions begin at the peritoneal layer it is perfectly possible for mechanical tension alone to produce only anterior sheath separation as was clearly demonstrated in case No. 24 when, during bronchoscopy on the operating table, the silk sutures of this layer all snapped.

Mechanical Stress and Postoperative Complications. There are two major forces which tend to cause the edges of an incisional wound to come apart, namely muscular pull and increased intra-abdominal pressure. Of the two I believe the latter is by far the more important. Drye and Griswold's ingenious studies¹¹ have shown that the increased intra-abdominal pressure associated with coughing, vomiting or hiccoughing is many times that accompanying movement or ambulation. Since all patients who have postoperative pneumonia

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or vomiting do not develop wound disruptions, and since all patients with wound disruptions have not had coughing or vomiting of note, these factors are obviously quantitative in their effect and associated with other conditions in bringing about disruption of a wound.

The two cases (Nos. 24, 35) in this series whose disruptions occurred as a result of tracheal stimulation on the operating table bear eloquent witness to the powerful mechanical forces which may operate. Here there was no question of wound healing or of the holding powers of the tissues or of an omental wedge mechanism—the sutures broke as a result of excessive force. (That both occurred in the presence of transverse incisions tends to substantiate previous statements concerning these incisions and with regard to the relative importance of the forces at play.) A third case (No. 3) is known to have had its onset in this manner; how many others had is conjectural. Marked elevations of the intra-abdominal pressure at any time after the incision is closed may initiate a small area of separation or enlarge a peritoneal tear produced during wound closure. This permits the entrance of the omental wedge into the wound and whether or not clinical disruption ensues will depend on the frequency and degree with which this force is repeated and on the inclination of the wound rapidly to heal. We may expect that with the increasingly frequent employment of endotracheal intubation in general anesthesia and awareness on the part of the anesthesiologist of the importance of keeping the tracheobronchial tree clean to prevent postoperative pulmonary complications, this sequence of events is apt to be on the uptrend, unless appropriate measures are enforced to prevent it. The solution is rather simple. When clearing the endotracheal tube by suction prior to withdrawal, as should be done, and whenever tracheal toilet or bronchoscopy is contemplated, the anesthetist should see that the patient is in a sufficiently deep plane of anesthesia when this is done so that violent cough reflexes are not stimulated. If he is reluctant to keep the patient under deep anesthesia near the end of the operation, he has the opportunity to call cautiously on the assistance of the curare preparations. A second, and probably preferable procedure, is to have the surgeon notify the anesthesiologist just before closing the abdomen. The tracheobronchial tree can then be thoroughly cleansed and only what has accumulated during the period of wound closure need be aspirated at the termination of the operation.

The cases in this series were reviewed with respect to anesthesia employed. Thirty-four cases had general endotracheal anesthesia with tracheal suction prior to withdrawal of the tube; one patient had straight general anesthesia and had tracheal suction on the first postoperative day. Eleven cases were done under spinal anesthesia. Three patients had postoperative therapeutic bronchoscopies.

Along parallel lines, it is of considerable interest to note that among 43 cases of postoperative disruption, severe and troublesome postoperative coughing was present in 26, often associated with pneumonia, atelectasis or bronchitis, and in seven additional cases a moderate cough was present, making a

total of 33. But if only the severe cases are regarded, it appears, nonetheless, that in approximately 60 per cent postoperative coughing contributed significantly to the disruption. In fact, in ten instances (Cases Nos. 5, 6, 17, 19, 21, 23, 29, 31, 36, 39) the patient reported feeling something give in the wound during a severe coughing seizure, in one case (No. 38) this occurred while vomiting, and in one case (No. 17) the wound popped open during an episode of acute pulmonary edema while the doctors were at the patient's bedside. In a few instances coughing was started by over-vigorous attempts at passing a Levine tube. In 11 instances among the 43, severe and frequent vomiting was a prominent feature, sometimes in addition to coughing, and appeared to be important in the disruption accident. In four instances distention was prominent as a precipitating factor and three patients had severe hiccoughs.

It is the author's personal opinion that these postoperative complications contribute significantly to the occurrence of wound separation. In most instances they are preventable. In the anteoperative phase the patient should be carefully evaluated and treated for chronic pulmonary complaints, whenever time permits. In the postoperative phase he should be instructed in and *made to perform* deep breathing exercises. Patients can be taught to raise bronchial secretions without strong coughing. Systemic penicillin will curtail the severity of pulmonary complications. We have found the use of nebulized penicillin, by aerosol inhalation, an invaluable postoperative aid. It should be instituted at the first sign of bronchopulmonary congestion. Aside from the antibiotic value of the penicillin, our experience is that the procedure encourages deep respiration and makes secretions easier to raise. In the anteoperative period it also has a large field of usefulness as a prophylactic measure. The same should also prove true of some of the newer antibiotics.

It has been properly observed that the stomach tube is to the surgeon what the stethoscope is to the internist. The routine use of the nasogastric tube (inserted before operation) in the patient undergoing an intra-abdominal procedure will prevent postoperative distention and vomiting³⁸ if attached to constant suction and kept patent. It need be retained only until the abdominal viscera have regained their tone and function. I, myself, have followed a rule that a patient is allowed to vomit no more than once without having a stomach tube passed. If the postoperative patient vomits despite the presence of a tube, then something is mechanically wrong and deserves immediate attention. Moreover, when a Levine tube is to be passed on a postoperative patient a few minutes invested in explaining matters to him and reassuring him, the use of mineral oil, sips of water and possibly, a bit of topical anesthetic and, above all, gentleness and patience in passing the tube, will all be rewarded by an absence of straining and struggling, which defeat the purpose for which the tube is intended.

Early Ambulation. Enough experience has now accumulated to state that early postoperative rising and ambulation, if properly supervised, do not jeopardize the integrity of the abdominal incision.^{7, 29, 34} In this series, 21 of 43 cases were ambulated during the first 48 hours. Since the usual practice on

the service is early ambulation in the absence of specific contraindications, this is a rather low figure in comparison with total experience. The inference is that early ambulation here certainly did not contribute to the disruption rate; a contrary influence is even suggested. This is borne out by the individual case analyses, in no one of which did early ambulation appear to have an adverse effect.

Treatment. The management of the case with a wound disruption depends upon the condition of the patient and calls for exercise of surgical judgment. If the patient's condition permits, then secondary operative closure is preferable; if not, resort must be had to tamponade and adhesive strapping.

Although many methods of secondary closure have been recommended, it is probably true, as Hartzell and Winfield concluded,¹⁹ that the type of closure employed has little to do with the ultimate outcome. In this series of 43 cases occurring after the patient left the operating room, 32 had secondary operative closure of the separated wound. Through-and-through sutures of wire or braided silk, alone, were used in 24 instances, six of the near-and-far variety, and in eight instances one or more layers were closed in addition to these sutures. No single method appeared to possess any distinct advantage. In one case, already mentioned (No. 7) closure with through-and-through wire sutures was followed two days later by copious sero-sanguinous discharge and at tertiary operation bowel loops were found in the depths of the wound and a tampon had to be used. In this case the patient had first been treated conservatively, without success, and after two operations for disruption, required another one for intestinal obstruction; he subsequently died. Obviously, if through-and-through sutures alone are used they should be fairly closely spaced. In another case (No. 15) where operative closure was delayed after the disruption was discovered (for five days) because of the patient's poor condition, an adherent loop of small intestine was injured and had to be resected. This patient recovered. A third case (No. 21), the McBurney wound disruption, closed with a peritoneal suture of continuous chromic catgut and through-and-through silk, had a third operation for intestinal obstruction 11 days later; no catgut could be found and there was little evidence of wound healing at this time.

In the group of 32 operative closures, four patients died and six had post-operative hernias, although some of the follow-ups are rather brief.

In the 11 cases treated conservatively, there were four instances of separation involving the anterior sheath only. There was one death in this group and six patients developed postoperative hernias. Two additional cases, first treated conservatively and then necessitating operation, have already been mentioned.

Regarding the choice of anesthesia for operative closure there has been considerable disagreement in the literature. In this series general anesthesia was used in 13 cases, spinal anesthesia in 14, regional block and local in two, local alone in one, and in one the anesthesia was not stated. I do not believe that the presence of a wound disruption should dictate the type of anesthesia

used in its repair. There are more important factors worthy of consideration, notably the age and condition of the patient, the presence of complicating diseases, and the skill and experience of the anesthetist available. The decision should rest upon sound clinical judgment rather than any hard and fast rule. If general anesthesia is chosen there are means of assuring a smooth induction to prevent straining and further evisceration.

Prognosis. The mortality resulting from wound disruption is generally considered to be high, varying from 20 to 85 per cent.^{7, 15, 17, 37, 38, 39} In this series there were five deaths giving a mortality figure of 11.1 per cent. The low rate in this recent series is partially a reflection of modern advances in surgery. In all, there were 14 hospital deaths, but in the remaining nine cases death occurred from 33 days to 14 months postoperatively, with healed abdominal wounds, and the disruption could in no way be related to their demise.

Of the five deaths, one patient (No. 7) died 35 days after disruption with an additional operation in the interval, and has already been discussed. One man (No. 8) died on the day following closure of the disruption when he pulled out a Miller-Abbott tube and started uncontrollable bleeding from esophageal varices (autopsy). Three patients died five days (No. 10), three days (No. 22) and 28 days (No. 45) post-disruption respectively, with the original disease and operation for it apparently bearing the brunt of the responsibility for their deaths.

Follow-up. Investigation of the follow-up status of the wound is not complete. Although it is stated that "hernia following disruption is generally considered to be a relatively infrequent complication, regardless of the method of closure,"¹⁹ this opinion is open to question. Grace¹⁸ found a high incidence. In this series, 38 cases could be subjected to follow-up analysis. Of these, 12 developed incisional hernias one month to 21 months postoperatively. Of the remaining 26 with sound wounds, 16 were followed for more than six months and 10 for fewer. Therefore, the incidence of postoperative hernia in this series is at least 31.6 per cent.

Summary. Carefully kept records indicate a 2.6 per cent incidence of wound disruptions among 1700 consecutive laparotomies. Since conflicting data and opinions in the literature stem chiefly from failure to consider the total group of abdominal procedures from which the disruptions are drawn, comparison was here made from the standpoint of patient's age, race, presence of cancer, type and location of the incision, suture material and method of closure. Results were subjected to statistical analysis for reliability wherever indicated. Careful clinical analysis also supplied valuable information.

Of the systemic factors concerned in wound healing, age, hypoproteinemia and, to a lesser extent, race, seemed to influence the frequency of dehiscence. Season of the year, vitamin C deficiency, anemia and sensitivity to catgut could not be indicted as significant determinants in this series. Cancer could not be divorced from age and other factors as a predisposing condition.

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The type and location of the incision did not seem to affect the disruption rate materially in this group, except for the McBurney type of incision, which afforded a high degree of protection. Placing a viscus, *i.e.*, performing a colostomy, gastrostomy, etc., in the incision, however, definitely increased the risk, while drains generally did not. Disruptions occurred in spite of retention sutures in several cases.

Care and technic in wound closure are unquestionably extremely important factors in wound healing, and the salient features are discussed. Atraumatic closure of the peritoneal layer is the most essential single aspect.

Postoperative complications, particularly coughing and vomiting, are pernicious influences and intensive efforts should be directed at their prevention and control. Early ambulation appeared to be without danger. Two disruptions occurred during tracheal stimulation on the operating table and others had their start in this manner. A method of prevention is suggested.

Clinically, many disruptions start much earlier than the day upon which they are discovered. Operative and conservative methods of treatment are discussed.

The mortality in this series was 11.1 per cent. Follow-up, even though incomplete, showed a significant incidence of incisional hernias regardless of method of management. Many incisional hernias result from unrecognized or concealed wound separations.

Conclusions. The seeds of wound disruption may be present before the patient goes to the operating room. Wound separation is often but one stage in a sequence of operative and postoperative complications of seemingly minor import at onset: Diminishing the rate of occurrence then, demands of the surgeon knowledge and application of the principles of surgical physiology, understanding of the wound and its healing processes, development of a careful and kindly surgical technic, an ability to recognize and meet the special operative needs of a given situation, and a willingness to devote unremitting attention to an infinite number of details in the ante-operative, operative, and postoperative care of the patient.

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DELAYED SUTURE OF SENSORY NERVES OF THE HAND*

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THE RESULTS of immediate suture of severed nerves in the hand are excellent, as has been shown by the work of Koch,¹ Bunnell,² Mason,³ Marble, Hamlin and Watkins,⁴ and others. Our interest in the repair of these nerves was heightened by the large number of old nerve injuries that were seen and operated upon at one of the large hand centers established by the army during the past war. Many patients were seen with previously unrecognized or ignored severed sensory nerves damaged two or more years before. Practically all had multiple associated injuries of soft tissue, bones and joints, necessitating extensive additional reconstructive surgery. In addition one or more digits or entire rays were often missing. All of these factors further increased the need for sensation to obtain a functional though often not a perfect hand.

In an effort to evaluate the results following repair of nerve injuries in the hand, an intensive study was carried out on every patient who had nerve repair done during a consecutive six-month period. A total of 71 sensory nerves were repaired during this time, many during the course of other operative procedures on the hand or fingers (Fig. 1). In 55 cases the median nerve and its branches were involved and in 16 cases the ulnar (Table I). There were no radial nerves repaired in this six month interval nor were any motor nerve repairs considered in the results. The site of suture is shown in the table. By cable graft, we refer to suture of several branches into one strand, followed by union of that strand or cable to the larger branch or trunk proximally. Under trunk repair, we refer to suture of a nerve at a level proximal to at least two branches.

All patients were thoroughly examined at close intervals during the first three months, since no patients were discharged prior to a three-month follow-up. Most of the patients were personally examined for longer periods of time up to one year. Follow-up letters were sent to every patient one year after operation. These letters were designed to make it as easy as possible for the patient to describe the return of sensation in simple terms.

Regeneration was determined by response to pressure touch, light touch, pin prick and two point discrimination. Response to temperature changes were not followed completely in all patients, since it soon became apparent that

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extreme changes in temperature returned at approximately the same rate as deep pressure and finer gradations were correlated with response to light touch.

It is admittedly difficult to evaluate results in nerve suture without close personal follow-up over a period of years, since nerve regeneration is a slow process. However, precise answers to specific questions in follow-up letters were obtained from all but three patients. In these three instances, the findings at the last examination were included in the final results.

Results are grouped for purposes of simplicity under three major headings according to the progressive return of sensation (Table I). Coarse touch returned first and is classified as pressure touch. This returned in 69 (95 per cent) of the 71 cases. Light touch and response to pin prick followed and were present in 61 cases (86 per cent). In ten instances (14 per cent) two point discrimination was fully developed one year after suture. In only two cases (2.8 per cent) was there no return, and in one of these, repair of the ulnar nerve at the base of the palm, failure of return was confined to only one half of one finger.

It was clearly evident that the more distal the repair, the more rapid and complete the return. Coarse touch had returned to the finger tip in every proper digital nerve repair within three months, and in over 50 per cent of all repairs regardless of the level, in the same time (Fig. 4). While response to pin prick and fine touch was slower to return, the same relation between level of repair and rapidity of return was true (Fig. 5). Bunnell² has shown that regeneration of nerves in the hand takes place at the rate of one finger segment a month.

There appeared to be no significant difference in the rate or completeness of sensation return between ulnar and median nerves in this small series of cases. However, in those instances where a cable suture was necessary, the end result was not so satisfactory one year following repair as where end-to-



FIG. 1.—Severed digital nerve on radial aspect of index finger with compound, comminuted fracture of proximal and middle phalanges and extensive loss of skin. Arthrodesis of middle joint in semi-flexion, repair of nerve and one stage tube pedicle flap was done at the same operation. Return of sensation was complete in four months.

TABLE I.—*Return of Sensation One Year After Repair of Sensory Nerves in Hand Severed Up to 30 Months Prior to Operation.*

Nerve	Location of Suture	Nerves Sutured	Partial or None	Return of Sensation		
				Pressure Touch	Light Touch and Pin Prick	Two Point Discrimination
Median (55)	Proper digital					
	Finger.....	4	..	4	4	4
	Palm.....	5	..	5	5	2
	Common digital.....	18	..	18	18	1
	Cable					
	Proper digital to common..	2	..	2	2	..
	Common or proper digital to trunk.....	12	..	12	5	..
Ulnar (16)	Trunk.....	14	..	14	14*	..
	Proper digital					
	Finger.....
	Palm.....	1	..	1	1	1
	Common digital.....	8	..	8	8	2
	Cable					
	Proper digital to common..	2	..	2	2	..
	Common or proper digital to trunk.....	2	1†	1	1	..
	Trunk.....	3	1‡	2	1	..
Totals.....		71	2 (2.8%)	69 (95%)	61 (86%)	10 (14%)

* Epicritic return spotty or incomplete in a few fingers, but definite return present in every finger represented.)

† Patient followed for six months only with no return in that time.

‡ One side of one finger had no return and return only partial in remaining distribution.



A

B

FIG. 2.—(A) Complete severance of median nerve at the base of the palm with severe nutritional changes and stiff finger joints, repaired 17 months after injury, showing extent of flexion before operation. Note glossy appearance of skin. (B) Extent of flexion and appearance of fingers nine months following nerve repair. Light touch present.

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end repair of a single nerve was performed (Fig. 5). This probably represented a mechanical factor in surgical technic. The age factor was not considered pertinent, since all patients were in the younger age group.

Unquestionably, in our series, a year is too short a time to judge complete return of sensation because of the many repairs done in the palm. This is borne out by the answers given by several of the patients to the questionnaires sent out. For example, one patient writes that "my hand is beginning to feel



FIG. 3.—(A) Stiff interphalangeal joints secondary to completely severed ulnar and partially severed median nerve, operated upon six months following injury, with no improvement in joint motion one year later despite return of pin prick and light touch. (B) Long and ring fingers arthrodesed in semi-flexion at middle joint.

normal during the past two months," but he adds that he is unable to distinguish objects by touch alone as yet.

The return of feeling as related to the time interval between injury and repair is significant (Table II). With the exception of three cases operated upon immediately after injury during the six-month period, the average time between severance of the nerve and repair was $17\frac{1}{2}$ months. The majority of the patients had sustained their injuries more than a year and a half prior to repair and many had gone more than two years before the nerves were repaired. The longest time was 30 months. Still, the return of sensation was excellent and the results show conclusively that a prolonged time interval

following injury was not a greatly significant factor in the rapidity and completeness of nerve regeneration. In 36 of 38 nerves (94 per cent) repaired 18 or more months following injury, coarse touch had completely returned and in 31 of these, fine touch and pin prick was complete to the tips of the fingers within one year. All 15 nerves operated upon between 12 and 18 months following injury showed at least coarse sensation and 12 of the 15 had return of fine sensation. It is the level of suture and not the time interval between injury and repair that is the important factor in rapidity of regeneration.

An attempt was made to correlate nerve regeneration to the nutritional state of the hand, but no definite conclusions could be drawn. The vast majority of these patients had sustained multiple injuries and had been submitted to multiple reconstructive procedures. In many patients with severe

TABLE II.—*Relation of Sensory Return One Year Following Nerve Repair to the Time Interval Between Injury and Operation.*

Number of Nerves Repaired	Time of Injury (Months)	Return of Sensation			
		None	Pressure Touch	Light Touch and Pin Prick	Two Point Discrimination
8	0-6.....	..	8	8	4
10	6-12.....	..	10	10	2
15	12-18.....	..	15	12	3
38	Over 18.....	2	36	31	1
71	Average 15*.....	2 (2.8%)	69 (95%)	61 (86%)	10 (14%)

* Eliminating three patients who were sutured immediately after injury, the average length of time between injury and repair of the nerve was 17.6 months. Longest time interval was 30 months.

nutritional changes, the regeneration was rapid, and return to normal appearance, good joint motion and normal skin temperature, quite satisfactory (Fig. 2). However, the nutritional changes in some instances were so severe by the time nerve suture was performed that even though sensation return was fairly complete, joint motion did not return due to irreversible changes (Fig. 3).

Scar tissue, secondary to associated injuries, appeared to play a deleterious part in regeneration. Every effort was made to provide a soft tissue bed at the site of repair. Where extensive cicatricial tissue was evident prior to surgery, this was excised and replaced with pedicle graft and the nerve repair delayed if necessary.

A tingling, uncomfortable sensation at the site of nerve repair, spreading to the distribution of the affected area, was present in six instances following repair. This was evident only when the site of repair was tapped sharply and was not disabling to the patient. It gradually became less noticeable, except in one patient who developed delayed wound infection.

In three cases severe pain developed at the suture site. At re-operation in one patient the nerve was found imbedded in dense scar with a small neuroma at the repair. In one case, the pain is gradually subsiding. The third patient,

in whom a digital nerve was repaired in the distal palm, has a persistent neuroma one year after suture and should be re-operated.

Technic of operation varied little. The most important factors were suture without tension and accurate approximation of nerve ends. Lysis of the nerves in the forearm was frequently done to make up gaps of up to two inches. Transplantation of the nerves at the elbow was done without hesitation to make up an additional two to three inches. Flexion of joints was usually necessary for relief of tension at the site of suture.

Fine black silk, No. 6-0, swedged on an atraumatic needle was used in every case, with sufficient interrupted sutures through the sheath to closely

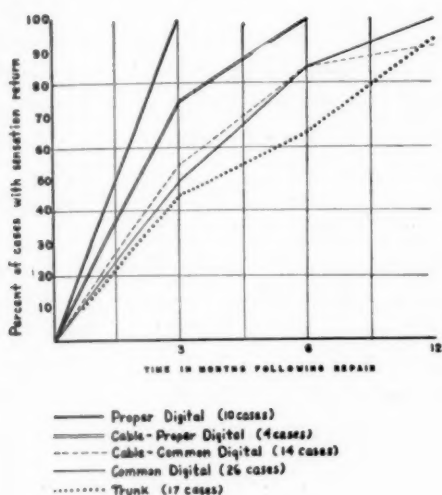


FIG. 4

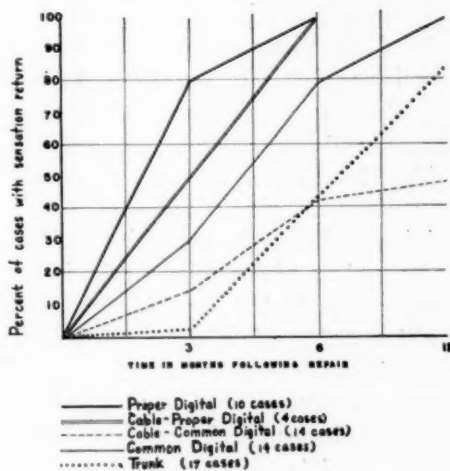


FIG. 5

FIG. 4.—Percentage of cases showing return of deep pressure sensation plotted against time interval in months following nerve repair.

FIG. 5.—Percentage of cases showing return of light touch and pin prick plotted against time interval in months following nerve repair.

approximate the ends. Following suture, the point of union was gently rolled between thumb and forefinger and a soft tissue bed assured at this area. Immobilization was maintained with splints in all cases for a minimum of three weeks and for longer periods of time with gradual straightening of the joints in those cases where a large defect existed prior to suture.

Where the defect was too great to permit primary union, nerve grafts taken from the sural nerve were used rather than to attempt repair under tension. No case where nerve graft was used is included in this series; however, the results in several patients followed appeared promising.

All operations were done in a bloodless field, using a blood pressure cuff for tourniquet, inflated between 250 and 300 millimeters of mercury. After-care consisted of occupational and physical therapy to help loosen joints.

DISCUSSION

A hand without sensation is little better than a hook, able to grasp but unable to differentiate between one object and another or describe the article grasped. The entire hand need not be insensitive to produce a disabling hand, for each finger or half a finger without sensation causes disability in proportion to the location of the insensitive areas and the fingers involved.

However, loss of touch alone is only part of the disability produced when sensory nerves in the hand are severed. Neuromas at the site of injury usually are present. Joint changes resulting in stiffness of the small finger joints, and trophic and nutritional changes are common. Burns, contusions, and ulcers are frequent sequelae in fingers with loss of sensation.

Despite the increasing interest of surgeons in reconstructive surgery of the hand, attention appears to be directed too easily to the obvious injuries present and complete sensory examination often not carried out. Skin loss, severed tendons, or fractures are easily diagnosed and the nerves overlooked, either because the preoperative diagnosis was never made or because of a persistent idea that these nerves are too small to repair.

Even in old injuries—the malunited fractures, adherent tendons, stiff joints—all may be recognized without full cognizance of the changes present due to loss of sensation to the involved portion of the hand. Certainly there appears to be lacking a knowledge of the results obtainable by proper recognition and repair of these specialized sensory nerves. Bunnell⁵ has stated that one is not qualified to repair injured extremities unless he has mastered the surgery of nerves. Injury to the small motor branches of the ulnar and median nerves also can and should be diagnosed prior to surgery and repaired whenever possible.

The results obtained in the cases presented make it appear worthwhile to explore every hand in which there is incomplete or absent sensation no matter how long a time interval has elapsed since the injury, if that loss of sensation is disabling. Of course the hand must be considered as a whole from a functional and economic standpoint. Certainly a digit with stiff interphalangeal joints and complete loss of sensation is better amputated if other fingers are normal. However, where there is any reasonable doubt, the gratifying results following delayed nerve suture make exploration the procedure of choice.

CONCLUSION

Immediate suture of sensory nerves in the hand and fingers has been known to give excellent results. The results following nerve repair were studied in a series of 71 cases operated an average of 16 months following injury. Eliminating three cases done shortly after injury, the average time interval was almost one and one half years, the longest being 30 months following injury.

All cases were followed for one year. In 69 (95 per cent) of the 71 cases, return of coarse touch was complete to the finger tips and in 61 cases (85 per

cent) return of light touch and pin prick was evident. In ten cases (14 per cent) two point discrimination also had returned. It was felt that the follow-up time of one year was not long enough to determine in how many instances complete return of sensation would be present.

Rapidity of regeneration was directly correlated to the level of the repair and not to the time interval between injury and repair. The more distal the site of repair, the more rapid and complete was the return of sensation in the year of follow-up study.

Nutritional changes, sometimes very severe at such a late date following injury, were often greatly benefited by nerve regeneration. In some instances the changes were irreversible and further reconstructive procedures had to be carried out after sensation had returned to give a functional hand. These latter cases make it even more apparent that the immediate recognition and repair of damaged nerves in the hand, both motor and sensory, are of primary importance in obtaining satisfactory surgical results in hand surgery no matter what associated injuries may be present. However, the gratifying results seen following repair of the sensory nerves when a prolonged time interval may have elapsed after the initial injury, make it worth while to explore every disabling nerve injury in the hand.

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CONGENITAL DIVERTICULUM OF THE POSTERIOR HYPHARYNX SIMULATING ATRESIA OF THE ESOPHAGUS*

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IN RECENT YEARS there has been an increased interest in congenital esophageal lesions because promising surgical technics for their correction have been developed.^{16, 18, 19, 24, 37, 53, 55, 56} The most common of these anomalies is atresia of the esophagus with tracheo-esophageal fistula; the upper esophageal segment ends blindly and the lower segment communicates with trachea or bronchus. The infant with such a lesion is unable to swallow, regurgitates feedings and mucus which collects in the pharynx, and soon develops pneumonia. The diagnosis is ordinarily made certain by means of swallowed lipiodol which collects in the blind upper esophageal segment. Roentgenographic demonstration of air in the stomach and intestine in such a case indicates the presence of a lower esophageal segment which communicates with trachea or bronchus, and such a case is likely to be amenable to surgical correction.

The following two cases present congenital anomalies which give identical symptoms and similar roentgenographic findings with swallowed lipiodol. In each instance atresia of the esophagus with tracheo-esophageal fistula was thought to be present and operative treatment was outlined accordingly. In each case the esophagus was entirely normal. Obstructive symptoms were due to the presence of relatively large posterior midline hypopharyngeal diverticula which had their mouths located above Cricopharyngeus fibers. Fluoroscopic and roentgenographic findings after the infants were given swallows of opaque material demonstrated a "blind upper segment" in each instance. In neither case was pharyngoscopy carried out before operation.

These congenital diverticula of the newborn are of interest because they mimic esophageal atresia in symptoms and roentgenographic signs. The pre-operative diagnosis of congenital pharyngeal diverticulum is necessary if a proper surgical approach is to be made.

CASE REPORTS

Case 1.—P. H., 48-13354, a white female, age 8 days, was admitted to the University Hospitals, Iowa City, Iowa, October 21, 1948. The birth weight was 5 lbs. 10 ounces. The infant regurgitated its formula and mucus and coughed with feedings. There had been no attacks of cyanosis. A local radiologist fluoroscoped the infant after giving a lipiodol swallow. No lipiodol entered the stomach. The lipiodol accumulated in "the upper esophageal sac" which reached down to third rib level posteriorly. The radiologist made a diagnosis of atresia of the esophagus. Three days after birth a

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gastrostomy was performed. This did not function well. The patient was transferred to the University Hospitals for operative repair of the esophagus.

Examination. The infant weighed 5 pounds. There was moderate dehydration. The cry was weak. Mucus accumulated in the mouth and pharynx, requiring frequent aspiration. There was no cyanosis. The lung fields were clear. The pulse rate was 130 per minute. A gastrostomy tube emerged from an upper left rectus abdominal incision. The abdomen was soft and flat. The hemoglobin measured 8.5 Gm. The red blood cell count was 3,940,000 and the white blood cell count was 18,500. A chest roentgenogram revealed the lung fields to be clear throughout. There was an air bubble in the stomach.

Preoperative Diagnosis. Atresia of the esophagus with tracheo-esophageal fistula.

Operation. October 21, 1948. Cyclopropane-oxygen anesthesia. Right posterior extrapleural mediastinotomy with resection of segments of third, fourth, and fifth ribs was carried out. The esophagus appeared normal externally. A catheter inserted through the pharynx met an obstruction at about second rib level. The esophagus was opened and catheters easily passed upward out of the mouth and downward into the stomach. (It was thought that an esophageal membrane had been perforated.) The operation was terminated.

Course. During the two-day period following operation it was noted that the patient was unable to swallow; she regurgitated feedings and mucus collected in the pharynx requiring lowering of the head and aspiration. Gastrostomy feedings were attempted but these feedings were regurgitated from the mouth. Lipiodol was injected through the gastrostomy tube under fluoroscopy. No lipiodol entered the duodenum. The lipiodol ascended in the esophagus to pharynx; then with swallowing, the lipiodol collected in a blind sac which seemed to represent upper esophagus (Fig. 1). Esophagoscopy was indeterminate; at the crico-pharyngeus a 1 to 2 mm. esophageal lumen was seen. An obstructing oblique membrane of the upper esophagus was thought to be present. It was thought that the gastrostomy was located close to the pylorus and was causing obstruction. Gastrostomy revision was planned.

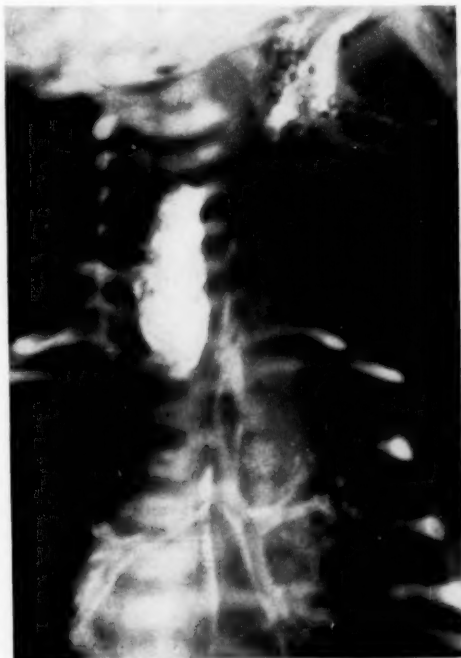


FIG. 1.—(Case 1, P. H.) Roentgenogram of the lipiodol-filled diverticulum.

Re-operation. This was performed October 23, 1948. Infiltration was made of 0.5 per cent procaine, with nitrous oxide-oxygen anesthesia. The left rectus incision was reopened and the stomach was exposed. The pyloric obstruction was due to hypertrophic pyloric stenosis. Hypertrophic pyloric musculature was divided (Ramstedt procedure)⁵³ and the gastrostomy was revised. A small catheter was led through the pylorus into third portion of duodenum.

Course. The respirations and color were good. Mucus collected in the pharynx and was intermittently removed with suction. A chest roentgenogram revealed a small right pneumothorax and some consolidation in the upper right lung field. Formula was administered in small amounts through the gastrostomy tube and was retained and well

tolerated. Cervical mediastinotomy to explore the upper esophagus was decided upon.

Re-operation. This was performed October 24, 1948. Infiltration was made of 0.5 per cent procaine, with nitrous oxide-oxygen anesthesia. An oblique incision was made anterior to the left Sternocleidomastoid muscle and the larynx, trachea, pharynx and esophagus were exposed. A diverticulum two inches long and one inch in diameter was found arising from the posterior midline of the pharynx above the Cricopharyngeus level (Figs. 2 and 3). The diverticulum extended down the posterior mediastinum behind and was lightly adherent to the normal esophagus. The muscular wall of the diverticulum was separate from that of the esophagus. The diverticulum was excised and its pharyngeal opening was repaired in two layers with interrupted silk. The area was drained and the wound was partially closed.

Microscopic description of the diverticulum. Sections (Fig. 4) showed a fibromuscular pouch lined by mildly acanthotic stratified squamous epithelium. In some areas the epithelium was hyperplastic, but for the most part it was thin. The basal layer was

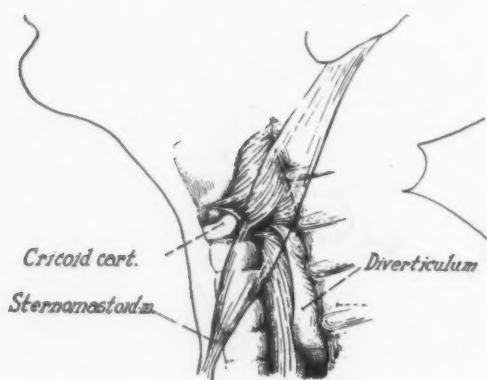


FIG. 2

FIG. 2.—(Case 1) Diagrammatic representation of the diverticulum *in situ*.

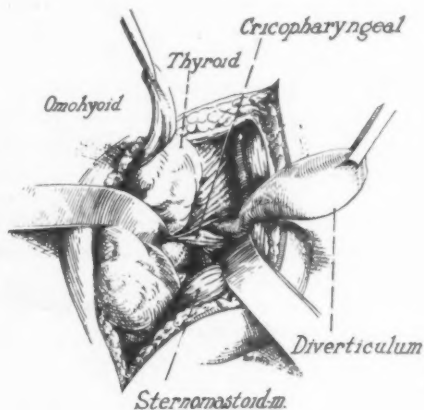


FIG. 3

FIG. 3.—(Case 1) Diagrammatic representation of the diverticulum at operation.

uniform without degenerative changes. A very thin muscularis mucosa was present. The submucosa was composed of fibrillary appearing fibrous tissue which was seen to extend into the underlying muscularis. A few nerve endings were present in the depths of the submucosa. The muscularis was composed of two layers, which showed considerable variation in thickness in different areas. The inner layer was predominantly longitudinal in direction with some obliquely placed fibers present. The outer layer showed a mixture of oblique and circular muscle fibers. The muscle throughout was histologically striated. Small mucus-secreting glands were seen deep in the submucosa and in the muscularis. The cells lining these glands were low cuboidal and many contained secretory droplets. All sections showed fairly pronounced vascularity as represented by numerous small vessels seen in cross section throughout the tissue. A few lymphocytes were scattered throughout all layers.

Course. The initial course was good. Aspiration of mucus from the pharynx was rarely needed. Gastrostomy feedings were well tolerated. One day after operation drainage from the neck incision indicated the presence of a pharyngeal fistula. A roentgenogram of the chest revealed a small residual right pneumothorax and partial

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collapse of the upper lobe of the right lung. Dye added to formula proved the presence of a pharyngeal fistula. On October 26, 1948, the patient became anuric. The rectal temperature, which had previously been normal, spiked to 101.6° F. The blood non-protein nitrogen measured 36 mg. per 100 cc. The plasma chloride level was 451 mg. per 100 cc. Renal function improved with administration of sodium chloride. On October 30, 1948, mild abdominal distention appeared. The temperature was normal and the color good. The patient's condition was quite good despite the pharyngeal fistula. On October 31, 1948, cyanosis appeared during intravenous administration of saline and glucose solutions. Plasma was given intravenously. A short time later, after a gastrostomy feeding, severe cyanosis appeared and the patient died at 2220 hours, October 31, 1948.

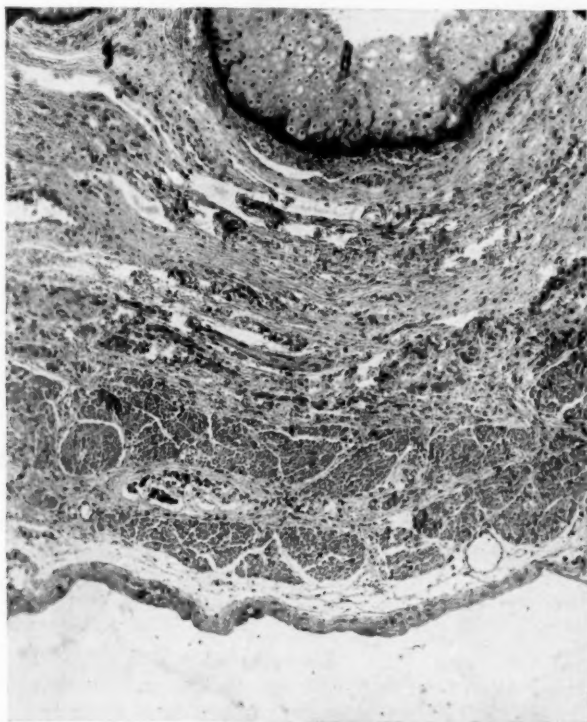


FIG. 4.—(Case 1) Longitudinal section of the wall of the diverticulum.

Autopsy. This was performed on November 1, 1948, 18½ hours after death. The chief findings were purulent mediastinitis due to a partial dehiscence of the pharyngeal suture line, pneumonia in the lower lobes of both lungs, lower nephron nephrosis and hyperplasia of pyloric musculature. The incision in esophagus had healed. The gastrostomy site was not remarkable. The pyloric obstruction had been relieved by operative division of hypertrophic muscle; the mucosa here was intact. Other viscera, including brain showed no abnormalities. Pus from the mediastinum cultured *Escherichia coli*.

Case 2.—A. D. C., 48-15942, a white male, age 2 days, was admitted to the University Hospitals, Iowa City, Iowa, December 29, 1948, because of regurgitation of

feedings and attacks of cyanosis since birth. The birth weight was five pounds. A barium swallow given by the local physician showed "atresia of esophagus."

Examination. The infant was small and weak, jaundiced and cyanotic. The cyanosis was relieved by oxygen administration. The infant's cry was weak and gurgling. Respiration was irregular and the rate was 35 to 40 per minute. The trachea was shifted to right. The upper half of the right lung field was dull to percussion and fine râles were heard throughout the right lung. No cardiac murmurs were heard. The hemoglobin was 17 Gm. The white blood cell count was 4050. Chest fluoroscopy revealed atelectasis of the upper lobe of the right lung and swallowed lipiodol passed to the third dorsal vertebra level and was then regurgitated and aspirated into trachea (Fig. 5). There was an air bubble in the stomach. A roentgenogram showed a relatively undilated "upper esophageal segment." Pharyngoscopy was not carried out.

Preoperative diagnosis. Atresia of the esophagus with tracheo-esophageal fistula.

Operation. December 30, 1948. Infiltration was made of 1 per cent procaine with nitrous oxide-oxygen anesthesia. Right posterior extrapleural mediastinotomy with subperiosteal resection of posterior segments of third, fourth, fifth and sixth ribs was carried out. The esophagus was normal. The anesthetist inserted two catheters through the mouth; one catheter ended in a diverticulum, the tip of which was located at the third dorsal vertebral level; the second catheter descended in the esophagus to stomach. There was no fistula between esophagus and trachea. The diverticulum lay posterior to the esophagus and, though lightly adherent to it, appeared to have a distinct muscular wall. Direct pharyngoscopy at this time revealed a normal esophageal opening, and just posterior and superior to this there was a slightly larger opening which led into the pharyngeal diverticulum. The operation was terminated. The patient tolerated the exploration well. It was planned to "invert" the diverticulum through an incision in the neck at a later date as the first stage of diverticulectomy.

Course. December 30, 1948, 2 hours after operation, the patient became cyanotic and respirations slowed to a rate of 5 to 10 per minute. After artificial respiration the patient rallied. A similar attack of cyanosis occurred 5 hours after operation. A roentgenogram of the chest showed atelectasis of the entire right lung with mediastinal shift to the right. There was no pneumothorax. The patient died 10 hours after operation in another attack of cyanosis and respiratory failure.

Autopsy. This was performed on January 3, 1949, 4 days after death. The chief findings were pulmonary congestion, pneumonia of the lower lobes of both lungs and pharyngeal diverticulum. The diverticulum began in the posterior midline of the pharynx just above the Cricopharyngeus fibers. It measured 1 cm. in diameter and 2.5 cm. in length. It extended downward in the posterior mediastinum, ending in a blind pouch lying behind the esophagus. Though the diverticulum was somewhat adherent to the posterior aspect of the esophagus, the muscular walls of these two structures were separate (Figs. 2b and 2c). The esophagus was normal in size, course and appearance.

Microscopic description of the diverticulum. Sections (Fig. 8) showed it to be lined by normal stratified squamous epithelium of uniform thickness. A thin muscularis mucosae was seen beneath the mucosa. The submucosa varied in thickness throughout the sections, in some areas being practically absent. It was composed of loosely-knit fibrillary fibrous tissue. In its meshes there were scattered small mucus-secreting glands. These glands were lined by low cuboidal epithelium, and many of the lining cells contained secretory droplets. The muscularis was composed of two layers. The inner, thicker layer was longitudinal in direction with occasional obliquely placed muscle bundles scattered through it. The outer layer was a mixture of oblique and circular muscle bundles. The thickness of the muscularis showed considerable variation in different areas of the sections. The muscle cells of the muscularis were rather immature, but in places did show the development of definite cross striations. There were a few nerve endings seen in the muscularis and deep layers of the submucosa. There was

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no increase in the number of blood vessels seen as compared to the sections of normal oral pharynx.

DISCUSSION

These two diverticula can be classified as congenital because they were present at birth and because they contain all layers of the structure from which they arise. Figures 4 and 8 show each diverticulum to be lined by

FIG. 5

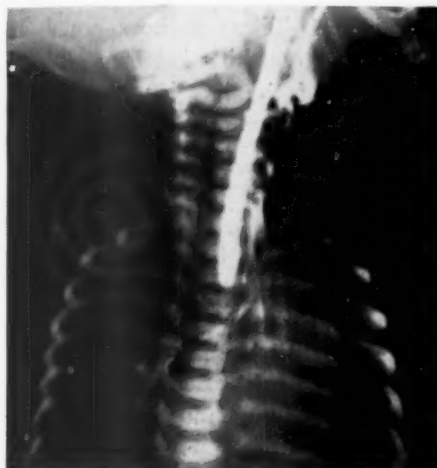


FIG. 6

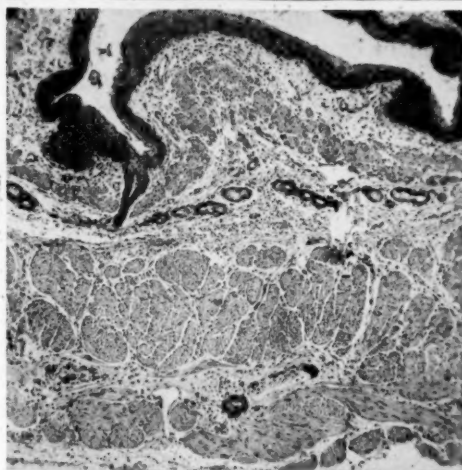
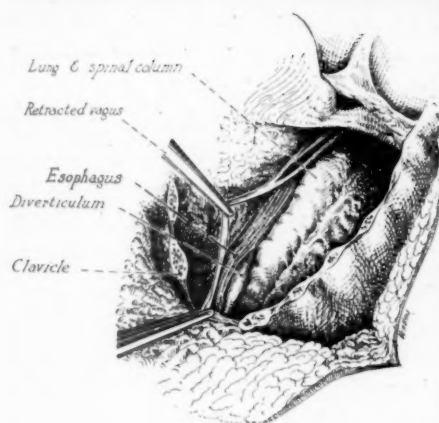


FIG. 7

FIG. 8

FIG. 5.—(Case 2, A. C.) Roentgenogram of the lipiodol-filled diverticulum with a catheter in the blind pouch.

FIG. 6.—(Case 2) Photograph of the diverticulum and upper end of the esophagus.

FIG. 7.—(Case 2) Diagrammatic representation of the photograph.

FIG. 8.—(Case 2) Cross section of the wall of the diverticulum.

stratified squamous epithelium. A very distinct muscularis similar to the muscularis of pharynx was found in the wall of each diverticulum. The muscle was of the striated type, and the fibers for the most part ran obliquely. Muscle fibers were present throughout the length of the diverticula, thus differentiating them clearly from pulsion diverticulum in which muscle fibers may be found near the neck of the sac. The origins of these diverticula were above Cricopharyngeus fibers; thus the sacs are pharyngeal rather than esophageal.

Pulsion diverticula of the hypopharynx are fairly common in elderly individuals. Excellent studies of pulsion diverticula have been made by Zenker and Ziemssen,⁶² Gallan¹² and others.^{21, 22, 33, 38, 60} These authors conclude that pulsion diverticulum develops as a mucosal outpouching between oblique fibers and transverse fibers (Cricopharyngeus) of the inferior pharyngeal constrictor where there is normally a weakness of the muscle coat of the pharynx, the so-called Killian's dehiscence or Lannier-Hackerman¹⁷ triangle. There is no evidence that pulsion diverticulum of the hypopharynx begins as a congenital diverticulum in this area.¹⁴ Zenker and Ziemssen⁶² discarded this concept in 1878 because of the lack of muscle layers in the walls of pulsion diverticula and because no such diverticulum had been described in the newborn or in childhood.

Diverticula of the alimentary tract are generally thought to have their origin in misplaced buds which retain communication with the parent organ.^{10, 36, 40} Diverticula ordinarily have the same type mucosal lining as the alimentary segment from which they arise, and have complete muscle coverings. Ladd and Gross³⁶ state that a reduplication and the true bowel segment have a common muscularis; thus a reduplication is strongly adherent to the adjacent alimentary tube. The two cases of posterior hypopharyngeal diverticulum presented here would seem to fulfill the criteria for true diverticula and their light adherence to the esophagus, and their distinct muscular coats would seem to satisfactorily differentiate them from reduplications.

Lateral pharyngeal diverticula have been described in the human being by numerous authors.^{4, 6, 8, 13, 22, 28, 30, 31, 32, 34, 44, 50, 52, 61} These lateral diverticula are rare, are congenital in nature, and are supposed to represent persistence of the second, third or fourth branchial pouches.

Centrally placed anterior diverticula of the pharynx are found regularly in the hog^{1, 46} and at times in some other animals.^{11, 20, 48} Hurst and Briggs²⁷ described an anterior pharyngo-esophageal pouch three quarters of an inch in length in a 57-year-old woman who had suffered from dysphagia and regurgitation for one and a half years. These authors felt that the pouch had developed through an anterior muscle weakness between muscle fibers of esophagus and the inferior pharyngeal constrictor. The diverticulum was not surgically excised, nor was autopsy carried out. Hill²² and Graham¹³ have referred to Hurst's case as a congenital anterior pharyngeal diverticulum for reasons which remain obscure. Raven,⁵⁰ in his embryologic and morphologic study of pouches of the pharynx and esophagus, classified such diver-

ticula as anterior acquired pulsion in type. It would seem that Hurst's case was more likely an acquired pulsion sac than a true congenital diverticulum.

The authors have been unable to find in the literature a description of a posterior hypopharyngeal diverticulum in the newborn. In numerous discussions of pharyngeal diverticula and their causes, no mention has been made of congenital posterior pharyngeal diverticula^{3-5, 8, 13, 21, 22, 38, 44, 45, 48, 50-52, 54, 55, 58, 61, 62}. Lubliner⁴² described briefly a lesion he found on esophagoscopy, a small diverticulum 2 by 3.5 cm. below the pharynx in an infant with esophageal atresia. Abel¹ stated "Congenital diverticulum at the pharyngo-esophageal junction is extremely rare, occurs in the same position as the acquired Zenker's pulsion diverticulum, and eventually produces similar symptoms." Abel does not cite any case to support his statement, nor do any of the articles referred to in his bibliography describe any congenital posterior pharyngeal diverticulum.

Cautley⁶ and others^{5, 61} stated that posterior pharyngeal diverticula did not occur in children. Contemporary authors^{7, 9, 15, 23, 25, 29, 39, 41, 47, 57} state that they have neither encountered nor heard of posterior pharyngeal diverticulum in the new born. Congenital diverticula of the esophagus proper, located well below the pharynx, have been described by Arnold,² Luschka⁴³ and others.^{26, 30, 35, 50, 59}

Although fluoroscopic examinations and roentgenograms in these two cases of congenital diverticulum failed to demonstrate any swallowed opaque material passing down the normal esophagus, the presence of air in the stomach in the absence of tracheo-esophageal fistula indicated that the esophagus was, physiologically at least, partially patent. There seemed to be no definite roentgenographic criteria which would serve to distinguish congenital posterior pharyngeal diverticulum from esophageal atresia with tracheo-esophageal fistula. In this regard, we must make note of the narrow sac in the second case (Fig. 5). In the first case the lipiodol filled sac was dilated and did not differ in contour roentgenographically from a lipiodol filled upper esophageal segment in esophageal atresia. Pharyngoscopy in the first case was inconclusive; the esophagoscope passed into the diverticulum and the slitlike esophageal aperture which was located anterior to the diverticulum was thought to represent a cleft in an esophageal membrane. In the second case, pharyngoscopy performed at operation, after a normal esophagus was found on exploring the mediastinum, revealed clearly the apertures of esophagus and diverticulum; the relationship of diverticulum to esophagus was then demonstrated by passing catheters into each of these openings. In the future we plan to pharyngoscope cases of "esophageal atresia" preoperatively and we believe that by so doing we will recognize congenital posterior pharyngeal diverticulum.

Diverticulectomy in the first case was unsuccessful due in large part to breakdown of the pharyngeal closure. This closure was carefully carried out with a closed technic and two rows of sutures were used. The closure appeared to be accurate and without tension. Despite careful closure, the

suture line necrosed postoperatively. This suggested that removal of such a diverticulum in a newborn infant should perhaps be "staged," the first stage to consist of elevation of the tip of the sac by suturing it high beneath the Sternohyoid muscle.³⁸ The second case would have been treated by a two-stage diverticulectomy, had the patient survived long enough to be operated upon.

SUMMARY

1. Two cases of congenital posterior midline pharyngeal diverticulum are reported. Apparently this lesion has not been described previously.
2. These diverticula are important lesions, as they produce symptoms and signs usually associated with esophageal atresia and tracheo-esophageal fistula in the newborn. Pharyngoscopy should differentiate diverticulum from atresia.
3. A two-stage removal of such diverticula may be safer than one-stage extirpation.

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RETROPERITONEAL HEMORRHAGE FOLLOWING LUMBAR SYMPATHETIC BLOCK DURING TREATMENT WITH DICUMAROL*

REPORT OF A FATALITY†

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Anticoagulant therapy has recently been added to the other forms of treatment used for acute frostbite.¹⁻⁴ These included paravertebral sympathetic nerve blocks,⁵⁻⁷ aseptic pressure dressings⁸ and gradual elevation of skin temperature. The danger of concealed hemorrhage following paravertebral punctures during effective Dicumarol therapy is illustrated by the presented patient who died from a massive hemorrhage 96 hours after lumbar block.

CASE REPORT

A semi-stuporous white male, age 80 years, was admitted to the Cook County Hospital at 1:30 P.M. on December 22, 1948. While acutely intoxicated he had fallen asleep in a gangway from about 4:00 A.M. to 1:00 P.M., when he was found. The temperature was between 15 and 20 degrees above zero Fahrenheit.

Physical examination was essentially negative except for his semi-stuporous condition, the odor of alcohol on his breath, bilateral cataracts and the condition of his extremities. The hands were reddened and slightly swollen, but there were no blebs. An old flexion contracture was present on the fourth finger of his right hand. Both feet were cold and pale, with patchy areas of cyanosis extending about one inch above the malleoli on the right ankle and to just below the malleoli on the left ankle. The dorsalis pedis and posterior tibial artery pulsations were absent bilaterally. Laboratory examination of the blood was negative; the hemoglobin was 85 per cent. The urine showed 3 plus acetone but was otherwise negative.

The diagnosis of acute frostbite of the lower extremities was made and treatment started within one-half hour after admission. Bilateral lumbar paravertebral blocks were performed; the routine procedure consisted of inserting 8 cm. 22-gauge needles just lateral to the vertebral body of L₂, L₃ and L₄ and injection of 10 cc. of 1 per cent procaine solution into each site or a total of 30 cc. on each side.¹⁰

Anticoagulant therapy was instituted one hour after the lumbar blocks. After the blood prothrombin level was obtained 50 mg. of crystalline heparin was given intravenously and 200 mg. of Dicoumarol was given orally. The heparin injection was repeated every 4 hours for 8 doses until the Dicumarol became effective. Daily blood prothrombin activity was determined before deciding upon the dose of Dicumarol to be given. The paravertebral blocks were continued daily for 7 days by the anaesthesiology department; on the second day the block was done 4 hours after the fifth heparin injection and the sixth heparin injection delayed for 1 hour. Figure 1 shows the daily prothrombin level, the dosage of Dicumarol and the daily lumbar blocks. A total of

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1350 mg. of Dicumarol was given. Convalescence was uneventful and only small areas of superficial necrosis developed on the toes of the right foot.

On the eleventh day after admission, about 3:00 A.M. Sunday, January 2, 1949, the patient was found to be in shock. He was pale, perspiring and moderately dyspneic, although he stated that he felt fine and had no complaints. The pulse was 98 and irregular. Basal râles were present in both lung fields. The heart tones were distant, but no murmurs or friction rub could be detected. The impression of the house officer was a probable coronary occlusion despite the anticoagulant therapy, and appropriate cardiac therapy was instituted.

Later in the morning the patient was examined carefully by one of us (W. R. O.). There was no evidence of external hemorrhage from any body orifice or of subcutaneous ecchymosis or petechia. Examination of the urine and stools for blood was negative.

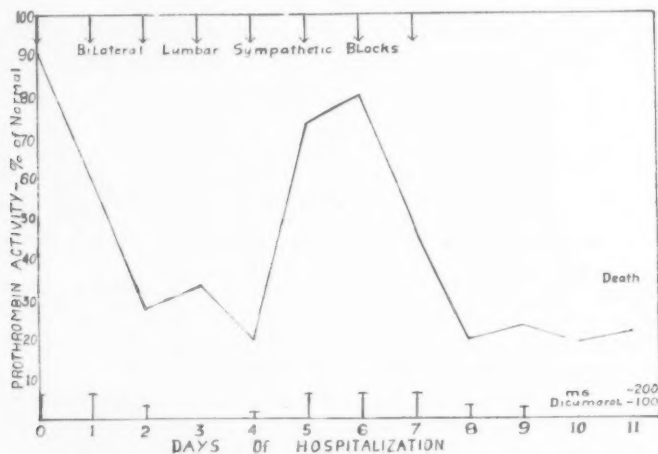


FIG. 1.—Daily prothrombin level, dosage of Dicumarol, and days on which lumbar sympathetic blocks were done. Note that death occurred 96 hours after the last lumbar block and 48 hours after the last Dicumarol medication was given. The prothrombin level remained in the accepted effective and safe level and there was no external evidence of bleeding.

No bleeding occurred at the site of venipuncture for the prothrombin blood specimen. However, the patient was still in shock as evidenced by cold clammy extremities, a pulse rate of 124, respiratory rate of 32 and blood pressure of 45/35. The abdomen was distended but not tender and bowel sounds were present. An emergency electrocardiogram revealed artefacts and was non-informative. The patient expired shortly thereafter. Except for the prothrombin determination no blood studies had been made because of the absence of external bleeding and the diagnosis was coronary occlusion.

Autopsy, performed by Dr. Wm. P. Mavrelis, revealed marked generalized arteriosclerosis. The pleural cavities contained about 300 cc. of blood tinged serous fluid and the lungs were congested and edematous. The spleen showed posthemorrhagic reactive hyperplasia. A massive hemorrhage estimated to contain about 2 to 3 liters of liquid blood was present in the left retroperitoneal space extending from the diaphragm to the inguinal ring. The bleeding appeared to have occurred deep in the left psoas muscle and to have spread through the loose areolar connective and fat tissue. Closer examination revealed several areas of hemorrhagic necrosis in the psoas muscle from which oozing of blood occurred. There was no evidence of an aneurysm or rupture of a blood vessel. The blood was not organized and the hemorrhage was apparently two or three days old.

COMMENT

The cause of death was a massive hemorrhage in the left retroperitoneal space; the bleeding originated from the psoas muscle where the needles were introduced for the paravertebral block. At the same time there was a Dicumarol induced hypoprothrombinemia within the recommended effective and safe therapeutic levels.^{11, 12} In spite of routine examinations for evidence of bleeding and careful control of the prothrombin deficiency, a concealed hemorrhage which occurred over a three-day period following lumbar block, was fatal.

DISCUSSION

The toxic effects of Dicumarol¹³⁻¹⁵ may be manifested by nausea, vomiting, diarrhea, and headache, but most commonly by an abnormal bleeding tendency.¹⁶⁻²² It is not unexpected therefore that trauma due to deep needle punctures could produce serious bleeding when a Dicumarol induced hypoprothrombinemia is at an effective level to prevent thrombosis.

Serious hemorrhage occurring from Dicumarol therapy is usually due to improper control of the drug,²³ to unreliable laboratory tests for determining the effective and safe prothrombin levels, to poor medical supervision of the dosage²⁴ or to the use of the drug when Dicumarol therapy is contraindicated. These contraindications^{11, 25} are hepatic insufficiency, marked renal insufficiency, recent operations or injury to the brain or spinal cord, blood dyscrasias with a tendency to bleed, pregnancy,²⁶ purpuras or ulceration of the gastrointestinal tract. Patients with granulating or ulcerative lesions, malnutrition, vomiting or gastric lavage, recent surgery or a history of a recent bleeding episode must be given Dicumarol with special care. Subacute bacterial endocarditis is now considered a contraindication to Dicumarol therapy²⁷ because of fatalities resulting from the use of the drug.

As a rule hemorrhagic manifestations are due to prothrombin deficiency. However, bleeding has been observed with prothrombin activity of 30 per cent while some patients will not bleed with a 5 per cent or lower prothrombin activity. Some investigators believe that a vascular factor may be present.²⁸ Vasodilatation of arterioles, capillaries and venules²⁹ has been observed and recently an increase in the coronary flow volume³⁰ has been reported. Heparin has been shown to cause a thrombocytopenia.³¹ Serious bleeding is usually prevented by maintaining a prothrombin level of 10 to 30 per cent of normal.^{11, 12} When the level falls below 5 per cent, or when there is evidence of bleeding, the drug is discontinued, and if necessary, corrective measures such as large doses of intravenous vitamin K^{32, 33} or fresh blood transfusions are taken.¹¹

Massive hemorrhage from lumbar sympathetic block has not been reported in the literature¹⁰ and we are unaware of any serious complications from the procedure. Even blind deep puncture of the aorta as recommended for arteriograms is considered a safe procedure.^{34, 35} The fatal hemorrhage must be assumed therefore to have been due to the Dicumarol induced hypopro-

thrombinemia, even though the safe therapeutic levels as advised by various authors were maintained.

Deep needle punctures should not be done on patients with Dicumarol induced hypoprothrombinemia. Such procedures include spinal puncture, thoracentesis, abdominal paracentesis and nerve or ganglion block. Barker³⁶ has also considered these procedures contraindicated during the effective period of Dicumarol induced hypoprothrombinemia. Intramuscular or subcutaneous injections and venipunctures are less dangerous, for the application of pressure over the site will hasten hemostasis and a hematoma can be detected. When nerve blocks are necessary the patient should be maintained on inter-

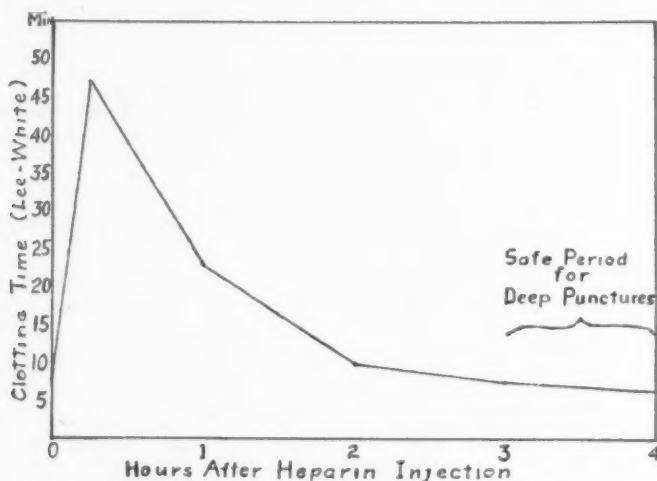


FIG. 2.—The effect of a single intravenous injection of 50 mg. of heparin upon the whole blood clotting time (two tube Lee White method³⁷). Normal clotting time returns for approximately the last hour of each four hour period and deep punctures may be done with relative safety during this period. However, the next injection should be delayed for one hour after the deep puncture.

mittent heparin therapy. The block can be done four hours after the heparin injection and the next injection delayed for one hour (Fig. 2). This routine was followed in our case for 48 hours.

SUMMARY AND CONCLUSIONS

A fatal case of massive retroperitoneal hemorrhage occurring four days after paravertebral lumbar block, but during the period of effective Dicumarol induced hypoprothrombinemia, is reported. No other source of bleeding occurred in this patient and the prothrombin level was continually maintained within the accepted safe levels. The marked arteriosclerosis could have been a factor in the failure of a traumatized artery to contract. The exact source of bleeding was not apparent at autopsy, although it appeared that the oozing occurred from the psoas muscle.

All deep needle puncture procedures are probably contraindicated during the period of effective Dicumarol therapy. When such procedures are necessary, intermittent heparin anticoagulant therapy should be given and the deep punctures made three to four hours after the last heparin injection and one hour before the next injection.

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UTILIZATION OF THE ROUND AND FALCIFORM LIGAMENTS AS A PERITONEALIZING STRUCTURE IN SURGERY OF THE UPPER ABDOMEN*

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HONOLULU, T. H.

PRESENT METHODS of radical resection of the stomach for malignant lesions involving removal of all the omentum along with the gastrohepatic ligament frequently leave little, if any, structure covered with peritoneum that may be utilized to reinforce lines of anastomosis, or to cover raw surfaces. For some years past it has been frequently found that the round and falciform ligaments of the liver may serve this purpose most adequately. It is surprising what a large amount of tissue of considerable length and width, covered with peritoneum and containing an adequate blood supply, can be developed by properly mobilizing the structures just mentioned.

The round ligament (*ligamentum teres*) is a tough, fibrous cord representing the obliterated umbilical vein. It arises at the umbilicus and extends upward to the umbilical notch of the liver, from which it may be traced along the under surface of the liver to the hilus where it becomes continuous with the *ligamentum venosum*. The falciform ligament, so named because it resembles the shape of a sickle, is a broad finlike fold of peritoneum that surrounds the round ligament and extends from the umbilicus upward over the anterior superior surface of the liver. At its base it is reflected laterally over the posterior aspect of the *linea alba* and *rectus sheaths* and above this over the under surface of the diaphragm (Fig. 1).

The peritoneum in the area of upper midline abdominal incision is very loosely attached to the abdominal wall, so that a considerable amount of peritoneum can be mobilized on either side of the round and falciform ligaments, and from which a pedicle flap can be formed and the abdominal incision be still closed without difficulty. The method of using this peritoneal flap is illustrated in the accompanying drawings.

When the peritoneum covering the lesser omental cavity is removed as it should be when total gastrectomy is performed for malignant lesions, the anastomosis posteriorly between the esophagus and the jejunum is less secure than it is anteriorly where peritoneum can be mobilized from the under surface of the diaphragm to cover the line of sutures. A flap of peritoneum fashioned from the round and falciform ligaments and used as shown in Figure 2, it is believed, adds materially to the security of this anastomosis.

In the presence of a ruptured duodenal or gastric ulcer the omentum is, at times, difficult to mobilize. This difficulty is due to its being adherent either to a previous laparotomy incision or to pelvic structures, the result of a previous inflammatory process. Occasionally the omentum is lacking, the

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result of a developmental anomaly. Recently a radical resection for carcinoma of the stomach was done in an individual whose duodenum could not be well turned in due to an old cicatrizing duodenal ulcer. Under these circumstances a pedicle graft of peritoneum used as shown in Figure 3 and Figure 4 has been found most useful.

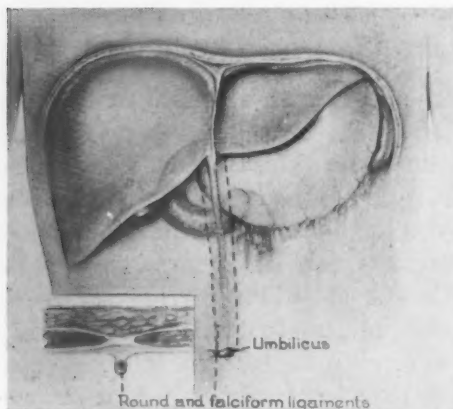


FIG. 1

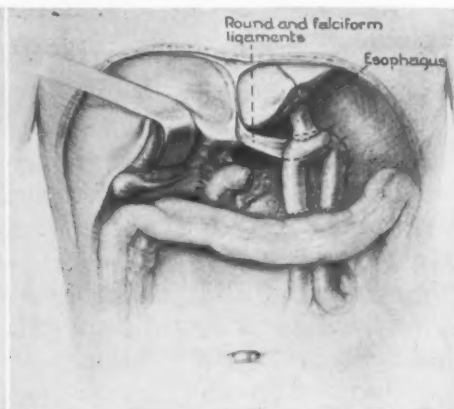


FIG. 2

FIG. 1.—This shows the anatomical relationship of the round and falciform ligaments to the liver and to the anterior abdominal wall. The dotted lines on each side of these ligaments represent incisions to be made in the peritoneum for mobilization of these structures.

FIG. 2.—A method is shown of using the round and falciform ligaments for reinforcing the posterior row of sutures at the anastomosis between the esophagus and jejunum in total gastrectomies.

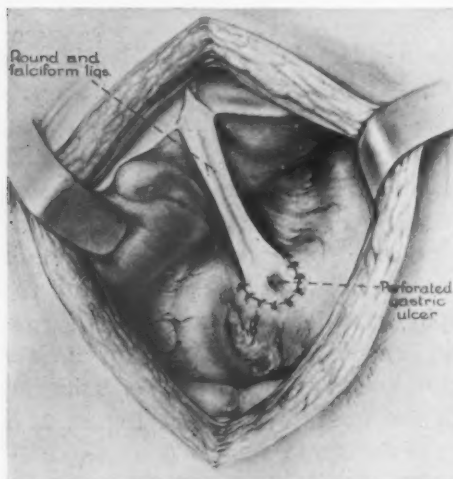


FIG. 3

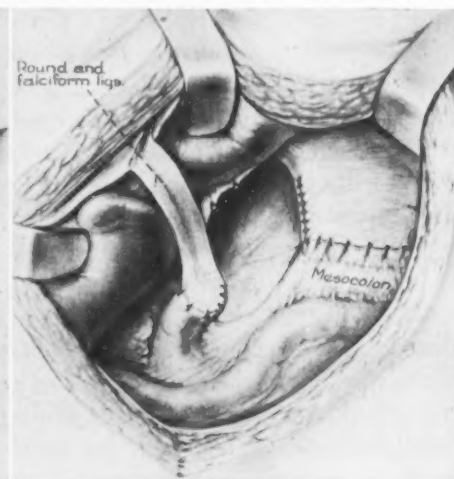


FIG. 4

FIG. 3.—Round and falciform ligaments, used to cover over a perforated gastric ulcer.

FIG. 4.—Round and falciform ligaments, used to reinforce the stump of the duodenum following gastric resection.

The indications for the use of this type of peritonealizing structure might be enlarged upon considerably but the examples presented would seem to suffice to draw attention to this method, to be used when simpler means are not at hand. No doubt others have had occasion to use the structures mentioned for the purposes described but if so I am not aware of it. At least, I do not believe abdominal surgeons in general appreciate the potential value of this simple maneuver.

THE SIGNIFICANCE OF RELAXED INGUINAL RINGS*

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THE PURPOSE of this paper is to report our findings as to the significance of the relaxed subcutaneous inguinal ring. This subject has been controversial for years with complete divergence of opinion as to its significance in subsequent hernia development. There has even been marked disagreement, as to what constitutes a relaxed ring. Da Costa¹ considered an external ring relaxed if it admitted an index finger. Gardner² considers any ring relaxed which is twice the size of an adult index finger with associated loss of muscle tone. Chassin³ states that the subcutaneous ring is considered relaxed, by most examiners, if it admits the tip of the little finger. He further found 78 per cent of 2,978 young males examined, to have subcutaneous inguinal rings which admitted an index finger with ease. Tobias⁴ feels that if the index finger is introduced comfortably into the subcutaneous ring it is relaxed. In our studies a ring, which comfortably admitted an adult index finger, was considered to be relaxed.

The material for this study was gained from reviewing 4000 health records at a large university. The vast majority of the examinations were done by four surgeons. The period covered was 1937-39 inclusive. A group of men not having relaxed rings examined during the same period was selected at random from the same group of records, and served as the control group. Both groups were then contacted by letter and asked if they had or had not had hernia repairs and if so on which side. The follow-up period, therefore, ranged between nine and 11 years from the date of examination. Table I graphically presents the data as to incidence and site of relaxed rings.

There were 392 relaxed subcutaneous rings in these 4000 men examined, or 9.8 per cent. The age group was young, ranging between 17 and 26 years, with by far the largest group in the 18 to 20 year range. Gardner² found a 13.7 per cent incidence of relaxed rings in 24,934 civil service employees. The age group in this series was a few years older than ours. Tobias,⁴ in 43,918 examinations, had an incidence of 6.85 per cent. The age group in his series was more nearly comparable to ours but apparently his subjects were army recruits who may have had some screening before appearing before him. Chassin³ using the strict criterion of the admission of the index finger as incidence of a relaxed inguinal ring had an incidence of 78.1 per cent in 2,978 examinations. A point that Chassin did not make, to explain his extremely high incidence of relaxed rings, is that his personnel were servicemen about to

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be separated from the service. It was the impression of one of the authors that the subcutaneous ring was much more readily examined in men ready for separation simply because many were pounds lighter and so had less adipose tissue in the pubic region to confuse the examining finger.

TABLE I.—*Incidence of Relaxed Rings According to Site.*

Site	Number	Per Cent
Right.....	82	20.9
Left.....	99	25.3
Bilateral.....	211	53.8

In our series, 53.82 per cent had a bilateral relaxation of the subcutaneous ring. Those having true unilateral relaxation were about equally divided between right and left sides. Furthermore, those with unilateral relaxation often had the opposite ring questionably somewhat lax. The high incidence of bilaterality supports a thesis that a relaxed subcutaneous inguinal ring is a result of a general body diathesis and not a result of any difference in descent of the testicle from the abdomen to scrotum.

Chassin³ found a high incidence of bilaterality, but Tobias⁴ found a much greater frequency of relaxed right ring; for, this difference we are unable to explain. Our findings were more nearly comparable to those of Chassin.

In our series, 14 persons with relaxed rings developed hernias over a period of nine to 11 years from date of original examination. In the same period the control group, those not having relaxed rings, had eight hernia operations.

TABLE II.—*Hernial Incidence—Followed Cases.*

		Number of Hernia	Percent Developing Hernia
Relaxed rings	274	14	5.1
Normal rings	273	8	2.9

Table II illustrates these points. Approximately the same percentage of subjects were traced at the end of ten years in both groups; 70 per cent among those with relaxed rings and 69.5 per cent of those with no relaxation were noted. Approximately 2.5 per cent of both groups were deceased at the end of the ten-year period. The remaining 27 per cent of each group were lost to follow up. Because the follow up was so nearly equal the results in the two groups may be directly compared. Computing our findings as to incidence of subsequent hernia formation in these groups one finds that Chi square is equal to 1.68 which is not statistically significant.

Table III shows the side of hernia repair in relation to the side on which the relaxed ring was noted at the time of original examination. One notes that

in all but two cases the hernia repair was on the same side as the relaxed ring. Our data do not explain these two cases who had repairs on the opposite side. It may be that both rings were relaxed at time of original examination or that an error was made in recording the findings, or that only the most obvious relaxed ring was noted. It is noteworthy that in three of the 14 cases bilateral repair was done although only one ring was described as relaxed at time of original examination.

This study produced several other observations. Twenty-two hernial repairs were done in a series of 782 persons. Fourteen of these had relaxed rings at the time of original examination and eight did not. Nine of the 22 herniorrhaphies were on the right side, six were on the left side and seven were bilateral. The slight but definitely higher incidence of right sided hernias is entirely in keeping with the findings of most other authors. In recently reviewing a series of 270 herniorrhaphies⁸ there was roughly a five to four incidence of right sided repairs as compared to those on the left.

TABLE III.

Case No.	Ring Relaxed	Hernia Repair
1.....	Left	Right
2.....	Right	Right
3.....	Bilateral	Bilateral
4.....	Bilateral	Right
5.....	Left	Bilateral
6.....	Bilateral	Left
7.....	Right	Bilateral
8.....	Bilateral	Right
9.....	Bilateral	Left
10.....	Right	Bilateral
11.....	Right	Right
12.....	Bilateral	Right
13.....	Right	Left
14.....	Left	Left

DISCUSSION

The results of this study support our impression that relaxed subcutaneous inguinal rings *per se* were of no great significance. We must hasten to add, however, that the series is none too large, and what is more important, the operative findings are not known to us. We do not know whether at the time of hernial repair a sac or lipoma of the cord, one or both, were found. Whether the hernia was direct or indirect or both is also, of course, not known.

Gardner² found that a person with a relaxed subcutaneous ring was twice as likely as a normal person to develop a hernia in subsequent years. Colcord⁵ doesn't feel that "relaxed rings" predisposes to subsequent hernia formation.

If prognostic importance in the subsequent development of inguinal hernia is to be attributed to a relaxed inguinal ring, it must be considered as no more than a manifestation of a general faulty construction of the inguinal region. Certainly the presence of a patent sac is of prime importance, and the strength

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and snugness of an internal ring coupled with an adequate transversalis fascia and abdominal musculature are likewise links more important than a relaxed subcutaneous ring.

SUMMARY

1. In 4000 examinations of college students there were 392 students (9.8 per cent) with relaxed subcutaneous inguinal rings. Fourteen of these followed ten years later had had hernial repairs.

2. In a comparable group without relaxed rings, there were eight who had had hernia repairs.

3. These findings suggest that prognosis of subsequent development of hernia can probably not be based on presence of a relaxed inguinal ring.

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A TWO-RIB INCISION FOR A SUBTOTAL ESOPHAGECTOMY*

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THIS IS TO REPORT the successful use of a two-rib incision for a resection of the esophagus with an esophagogastrostomy above the aortic arch. With the usual incision through the left chest¹⁻⁷ the operative exposure either high or low in the chest has been poor, especially for the dissection of the esophagus from under the aortic arch and for the anastomosis high in the chest. This difficulty has been previously avoided by (1) separate abdominal and right thoracic incisions, and (2) various types of left thoracico-abdominal incisions. The first type have the disadvantage of not being able to determine the operability before a major abdominal stage of the procedure has been completed. The second type have the disadvantage of being time-consuming, tedious, and quite traumatic to a patient already in poor condition.

DeBakey and Ochsner⁸ in 1948, after using the left thoracico-abdominal incision, suggested the use of a two-rib approach through the beds of the seventh or eighth ribs for the lower thoracic part and through the bed of the fourth rib for the superior thoracic part of the operation. They suggested the incision as being less traumatic, less time-consuming, and as designed to overcome the objections of the other incisions.

The incision used in this report was located over the left eighth rib from the costochondral end posteriorly to its angle, then superiorly to the level of the fourth rib. The eighth rib was completely removed to its angle posteriorly and 1 cm. segments posteriorly were removed from the ninth, seventh, sixth, and fifth ribs. After the subaortic esophageal dissection and transdiaphragmatic freeing up of the stomach had been completed, the fifth rib was removed and the superior esophageal dissection and esophagogastrostomy were more easily done. Removing the fifth rib added very little time to complete the incision and greatly shortened the total operating time by enabling a much easier and safer dissection of the esophagus from behind the aortic arch and a more accurate esophagogastrostomy.

CASE REPORT

W. L. W., a 22-year-old white male, was admitted to the U. S. Medical Center, May 3, 1948, with the complaint that he was able to swallow only liquids, and these with difficulty. In March, 1945, he swallowed a tablespoonful of lye crystals. Following this he felt a severe substernal burning and received almost immediate treatment of gastric lavage in a nearby hospital. He had continuous substernal pain and 10 days later was unable to eat solid food. He was treated unsuccessfully by esophageal dilatation and in May, 1945, a Janeway Gastrostomy was performed. Until December, 1946, he fed himself through the gastrostomy with milk, syrup and butter. At this time he was able

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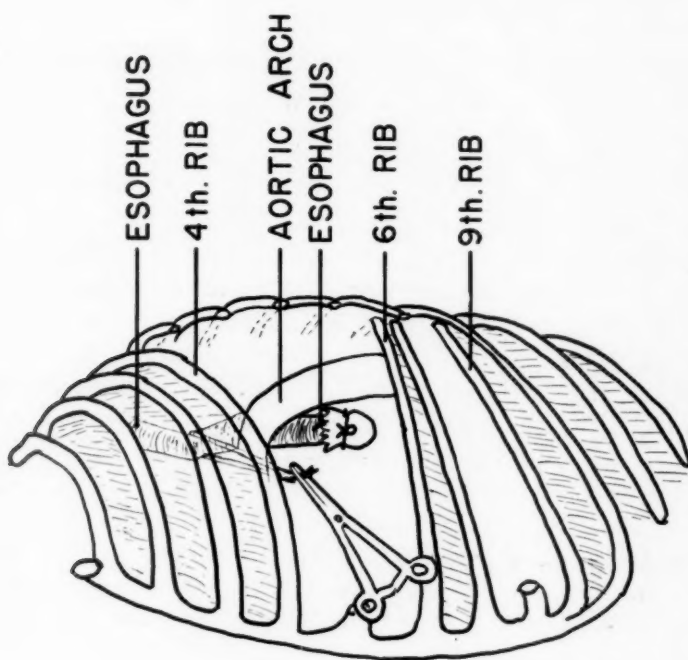


Fig. 2.—Exposure through bed of the fifth rib.

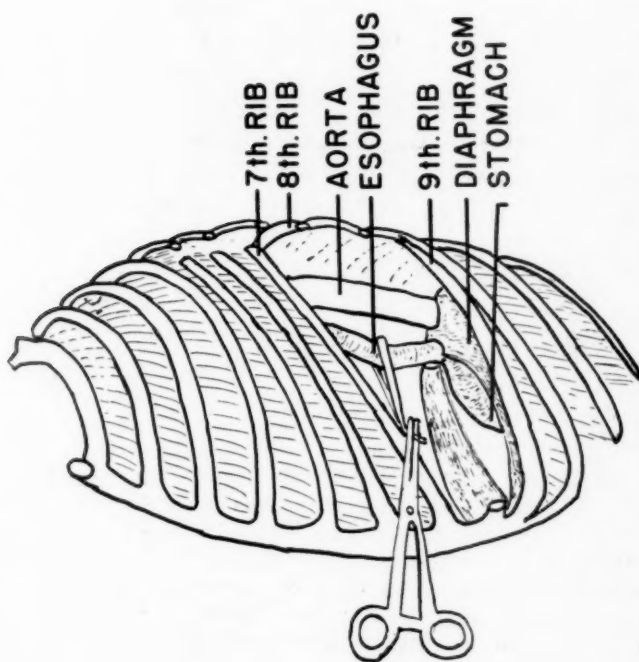


Fig. 1.—Lower thoracic exposure through bed of the eighth rib.

spontaneously without further dilatations to swallow his saliva and in April, 1947, the stricture had opened enough for him to swallow milk. The patient scarified the gastrostomy opening, causing it to close.

On admission to the Medical Center he appeared moderately well nourished. Except for the abdominal scar and acne, the general examination was essentially normal. Barium fluorographic and roentgenographic studies of the esophagus revealed a stricture at the level of the arch of the aorta with a thin trickle passing into the stomach. Esophagoscopy revealed the stricture as a pin-point opening 29 cm. from the upper incisor teeth. Routine laboratory tests and complete blood chemistry were within normal limits. After several unsuccessful attempts to dilate the stricture, an exploratory laparotomy was performed May 13, 1948. The stomach was found grossly free of any fibrosis from the lye and was then freed at the site of the previous gastrostomy and repaired with interrupted fine silk technic. The postoperative course was uneventful.



FIG. 3

FIG. 3.—The esophageal stricture preoperatively.



FIG. 4

FIG. 4.—The esophagogastrostomy postoperatively.

On June 3, 1948, under intratracheal ether-oxygen anaesthesia an esophagectomy was undertaken. The incision was made over the eighth rib and up posteriorly to the level of the fourth rib. The eighth rib was completely removed subperiosteally and a 1 cm. segment posteriorly was then removed from the fifth, sixth, seventh, and ninth left ribs. Through the bed of the eighth rib the mediastinal pleura below the aorta was opened and the lower thoracic esophagus was mobilized from its bed. The diaphragm was opened from the esophageal hiatus to the ninth costal cartilage with a radial incision. The stomach was freed sufficiently to bring it to the dome of the left chest. The arcades of the gastroepiploic and right to left gastric vessels were preserved. The esophagus was detached from the cardia of the stomach and the stomach was closed with a double layer interrupted fine silk suture technic.

The mediastinal pleura behind the left subclavian vein was opened and the dilated superior thoracic esophagus was partly dissected out. Because of the difficulty of doing

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this from so low, the fifth rib was subperiosteally removed and the rib spreaders changed. The esophagus was now much more easily freed from the aorta and superior mediastinum and brought out above the aorta. An end-to-side esophagogastrostomy was performed using a double layer anastomosis with interrupted fine silk sutures. The stomach was secured to the parietal pleura with additional silk sutures. The diaphragmatic incision was closed about the stomach and the chest wall was closed. A water seal drain was placed through the ninth intercostal interspace. Pericostal doubled chromic 1 sutures were used to approximate the ribs and the intercostal and chest wall muscles were closed with separate continuous chromic 1 sutures with cotton for the skin. He received 2,850 cc. of blood during the operation. Except for the incision, the details of the operation were as described by Sweet.²

The postoperative course was uneventful. He was put on a liquid diet on the fourth postoperative day which was graduated to a regular diet on the twentieth postoperative day. The waterseal tube was removed the fourth day and he was then allowed up and around the ward. For several months he had occasions of diarrhea and intercostal pain that cleared spontaneously. For about 6 months he regurgitated if he lay down immediately after eating; this was controlled by sleeping on two pillows. Now one year postoperatively he is symptom free, eats a regular diet, and engages in athletics.

Pathologic Report. A stricture of the esophagus at the level of the aorta was found, with a pinpoint lumen. There was complete replacement of the muscular coats with fibrous tissue in this area. The epithelium was intact. Sections below the stricture revealed fibrosis of greater or lesser degree throughout the entire lower esophagus with marked loss of mucous glands and some polymorphonuclear and round cell infiltration.

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"ABDOMINAL APOPLEXY" COMPLICATED BY MESENTERIC VENOUS THROMBOSIS

REPORT OF A CASE*

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Since "abdominal apoplexy," the rupture of an artery supplying one of the abdominal viscera, is a rare occurrence, reports of single cases are warranted. As recently as 1941 Cushman and Kilgore¹ collected only 21 cases, and in 1947 Tanna² collected 11 more reported cases and added three of his own, making a total of 35 cases. Of these patients, 28 were operated on with eight deaths in the group undergoing surgery. In five of the cases the bleeding point was found and ligated and only in the case reported by Crile and Newell³ was the problem handled by resection of the involved portion of the bowel. In the remainder of the surgical cases laparotomy only was performed.

The present case is of particular interest because not only was the original vascular disaster successfully treated by resection, but the patient's convalescence was complicated by a second abdominal vascular emergency of an entirely different nature, mesenteric venous thrombosis.

REPORT OF CASE

O. A. (7A752), a 61-year-old, Swedish born, white, single carpenter was admitted to the Surgical Service of the Peter Bent Brigham Hospital on February 24, 1948, because of abdominal pain. He had been well until 10 days before admission when, after lunch, he developed crampy lower abdominal pain and vomited several times. The following morning the pain shifted to the right mid-abdomen and upper quadrant and persisted until shortly before admission as a steady, not severe, rather "sickening" pain. During this nine-day period he had very little appetite and subsisted on a daily quart of milk plus an occasional egg. There was no further vomiting, no chills, fever, or urinary complaints. His bowels moved daily. About 5 hours before admission there was a severe exacerbation of the pain involving the entire right side of his abdomen with some radiation to the back, and he vomited several times. Although weak and giddy and in great pain he managed to get to his doctor's office where he received a large dose of morphine and was sent to the hospital.

In his past history there was an episode suggesting renal colic 15 years previously but with no recurrence. At about that time he had symptoms suggesting a peptic ulcer which subsided on a bland diet and antacids. Of considerable importance was the fact that for 2 years his systolic blood pressure had been known to be 200 to 225 although there had been no symptoms referable to this hypertension except for several spontaneous nosebleeds about 4 months previously.

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ABDOMINAL APOPLEXY

Physical Examination. The patient was a thin, dehydrated, well-preserved man, who was pale, perspiring, slightly cyanotic, somewhat cloudy mentally, and obviously in great distress. T.99 (R), P. 112, R. 24, B.P. 106/73. The pupils were pin-point in size, and the fundi could not be seen. The pulse was weak and thready and there was marked thickening and tortuosity of all the peripheral arteries, especially the right femoral, which was almost aneurysmal in size and consistency. The heart and lungs were normal to physical examination. The abdomen was flat, peristalsis was reduced but definitely present. There was spasm of the entire right side of the abdomen and marked tenderness in the right upper quadrant. Cough and rebound tenderness were present and were referred to the right side, not localized. There were no palpable masses or shifting dullness. Liver dullness extended 3 cm. below the costal margin, although the liver edge could not be felt because of spasm. Rectal examination was negative. No herniae were demonstrable.

Laboratory Data. Blood Hinton negative. Urine 1.026, pH 5.5, alb. O, sugar 2+, acetone 2+, sediment negative. Hgb. 11.7 Gm., Hct. 34 per cent, W. B. C. 14,400, 92 per cent PMN., 8 per cent lymphocytes, normal smear. No stool obtained. Emergency blood chemistries: Blood sugar 342 mg. per 100, CO₂ 20.4 m.m./l, Cl. 95 mEq/l, blood amylase 15 units. EKG showed minor variations that were not diagnostically significant. Roentgen ray examination showed the lungs to be clear, no free air beneath diaphragm, heart probably not enlarged, and the aorta tortuous. Abdominal film showed an enlarged liver, a probable left renal calculus and large calcified nodes in the pelvic region.

Hospital Course. Patient was given 1000 cc. 5 per cent dextrose solution, covered by 40 U. regular insulin. His blood pressure soon rose to 190/100. His pain rapidly increased. Within 3 hours his abdomen was silent, with generalized rebound tenderness, very marked spasm, becoming almost boardlike in all quadrants. He began to complain of pain in his right shoulder and at the base of his neck. Hematocrit was unchanged but W. B. C. rose to 25,000.

First Operation (Feb. 25, 1948). Laparotomy was performed 4 hours after admission with the tentative diagnosis of a perforated viscus, the duodenum, gallbladder and appendix all being under suspicion. Under gas oxygen ether anesthesia a short right rectus incision was made at the level of the umbilicus. On opening the abdomen the peritoneal cavity was found to be filled with fresh and old blood and large clots. The incision was enlarged and a blood transfusion started. Palpation revealed a large mass involving the ascending colon and on delivering this structure into the wound it was found to be black from blood dissecting beneath the serosa. There was also blood seeping from the lateral gutter. The discoloration of the bowel extended distally across the transverse colon nearly to the splenic flexure and proximally to the cecum. The terminal ileum, appendix and tip of the cecum were of normal appearance. There were many small hard nodules in the mesentery of the ascending colon which at first were thought to represent tumor implants but on closer inspection were found to be small arteries that were markedly calcified. The lateral peritoneal reflection of the ascending colon was divided and a large clot the size of two fists was evacuated from behind the bowel and its mesentery. This clot was the mass which we had palpated. It was by then obvious that some sizable vessel had ruptured. The actual point of rupture was not identified, but the margins of the normal bowel were obvious. A rapid resection of the right colon and about two-thirds of the transverse colon was carried out (Fig. 1). A Mikulicz type of resection was performed, a spur was made between the terminal ileum and the transverse colon near the splenic flexure, the double barreled ileo-colostomy was brought out through a short wound on the left side of the abdomen near the umbilicus, and the mesenteric defect was closed. The abdominal wound was closed in layers and the patient left the operating room in surprisingly good condition. He received 1000 cc. of citrated blood during the procedure.

Pathologic Examination. The specimen showed that one of the cecal branches of the ileo-colic artery had a cystic dilatation measuring 0.7 cm., a typical false aneurysm. This dilated portion of the vessel was lined with a thin gray wall which had ruptured and

the defect communicated with the large hematoma. The portion of the hematoma nearest this defect seemed relatively soft and fresh, while that at the periphery appeared firm and showed changes suggestive of early organization. The offending vessel was patent both proximal and distal to the area of aneurysm formation (Fig. 2). The pathologist's diagnosis was "aneurysm of the cecal branch of the ileocolic artery with rupture into the mesentery." Microscopic studies revealed "mesenteric atherosclerosis with rupture, false aneurysm formation and diffuse mesenteric hematoma."

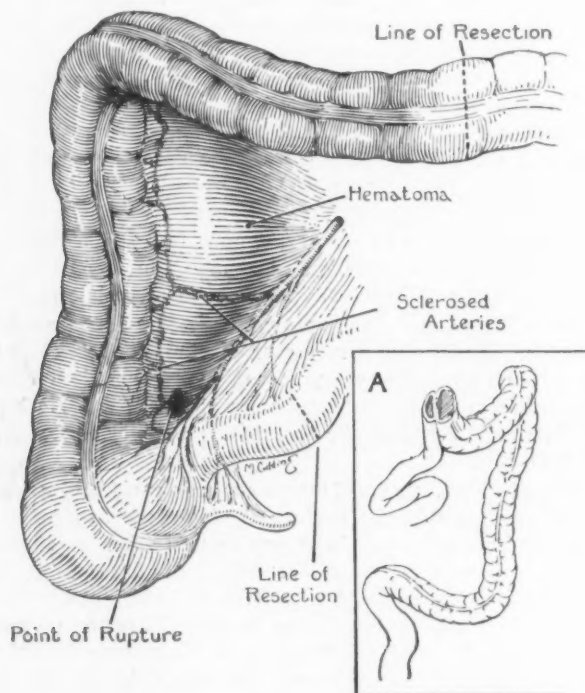


FIG. 1.—Situation at first laparotomy. A huge extravasation of blood behind the mesentery of the ascending colon, with blood dissecting beneath the serosa of the bowel. Insert shows operative procedure.

Postoperative Course. After this the patient did fairly well. He was given penicillin 100,000 U. every 3 hours. Further studies showed that he did not have diabetes. The protruding ends of bowel were inspected about 6 hours after operation and were of normal color. However, the following day it was noted that the colonic limb of the ileo-colostomy was slightly discolored, and this discoloration increased rapidly until 36 hours after the original operation, when it was obvious that the colonic limb was not viable. Meanwhile abdominal pain increased, the pulse became more rapid, and peristalsis had not been audible since the first operation. We thought that the colonic limb was too tight and that, therefore, its blood supply was inadequate. The patient was taken back to the operating room and a transfusion started.

Second Operation (Feb. 26, 1948). Under ether anesthesia, the abdomen was opened through a left rectus incision running down from the ileo-colostomy. It was discovered that not merely the tip of the colostomy was infarcted, but the entire remaining colon down to the upper sigmoid was a dusky gray-black color and obviously nonviable

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(Fig. 3). The infarcted area corresponded with the distribution of the left colic vessels. The patient's blood pressure dropped to around 100/70 from its preoperative level of 200/100. No pulsations could be felt except in the aorta itself. As rapidly as possible the left colon was resected down to the midportion of the sigmoid and another Mikulicz spur was constructed between the same loop of ileum previously utilized and the normal appearing distal sigmoid. The Mikulicz ileo-sigmoidostomy was brought out through the lower end of the operative incision, which was then rapidly closed with interrupted sutures of braided silk through all layers. Five hundred cc. of blood and 600 cc. of plasma were administered during this operation. At the end of the procedure pulse was 144 and blood pressure 90/70.

Pathologic Examination. This second specimen revealed an entirely different process than that seen in the previous specimen. The bowel was a mottled, grayish-black with

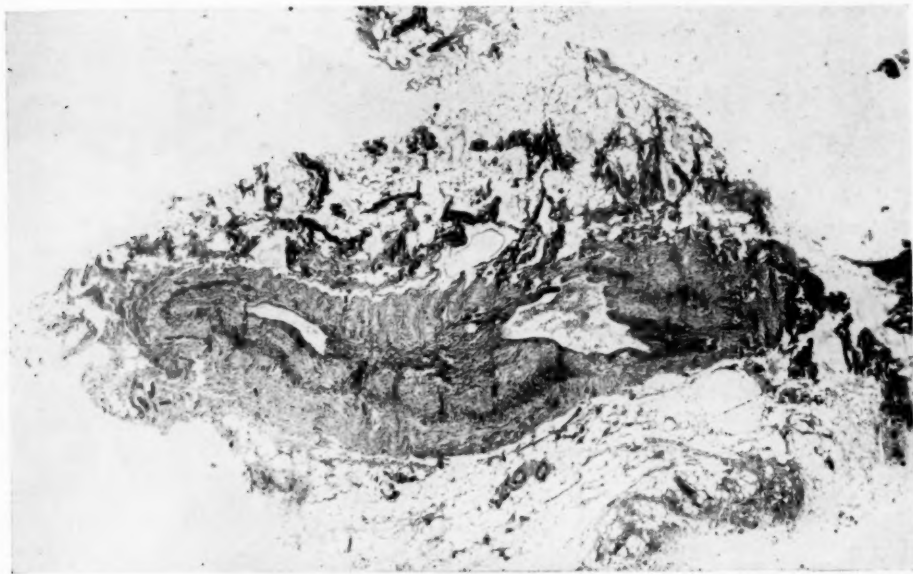


FIG. 2.—Branch of the ileo-colic artery showing marked arteriosclerotic changes plus thinning and threatened rupture of the wall. (Section made just proximal to the point of actual rupture and false aneurysm formation.)

many small areas of fibrinous exudate. The mucosal surface was dull and granular with many blotchy areas of petechiae and ecchymoses. On microscopic examination there was diffuse thrombosis of the mesenteric veins. The pathologic diagnosis was "thrombosis of mesenteric veins with infarction of transverse and descending colon."

Course. In the few hours following this second operation the patient improved somewhat but he remained critically ill for several days. Streptomycin was given for 4 days, 0.5 Gm. every 6 hours. He was maintained on heparin in doses of approximately 300 mg. daily in an effort to prevent thrombosis elsewhere. Penicillin, 800,000 u. daily, was administered. His nutrition was maintained by large amounts of whole blood, plasma, glucose, and "Amigen" intravenously. For a few days he improved but then again became sick and disoriented and had a sustained fever and rapid respirations. He developed dullness over the entire left chest. Roentgenograms on the tenth postoperative day showed the left chest filled with fluid, the lung being almost completely collapsed. Thoracentesis yielded 300 cc. of thick, pinkish, foul-smelling pus which on culture yielded *E. Coli*. This was all the pus that could be aspirated and obviously represented only a

small proportion of the total amount present. Accordingly closed drainage of the chest through a No. 16F rubber catheter in the eighth interspace was instituted. Ory, Jackson and Finland⁶ had reported successful treatment of Gram negative bacillus empyema with intra-pleural penicillin and this was tried. Through a "Y" connection, 10,000 U. of penicillin in 100 cc. of saline was allowed to run into the pleural cavity every 2 hours. An hour after each instillation the lower arm of the "Y" was unclamped and pus plus irrigating fluid was allowed to run out into a flask with an underwater seal. After two days, streptomycin was added to the irrigating fluid in such quantity that 0.1 Gm. streptomycin and 10,000 units of penicillin were administered every 2 hours, in addition

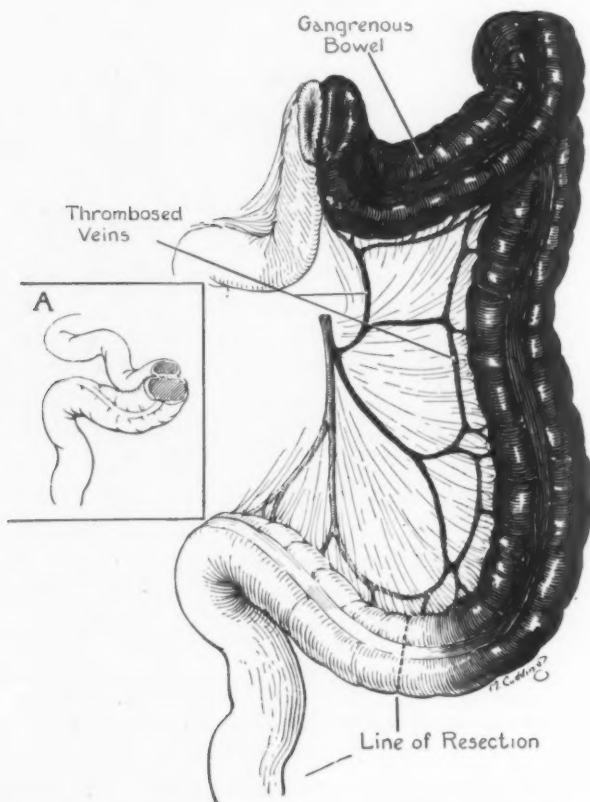


FIG. 3.—Situation at second laparotomy. The large bowel was infarcted and gangrenous down to the upper sigmoid. Inset shows operative procedure.

to parenteral antibiotics. Drainage was very profuse for the first few days and then decreased. After 6 days of drainage, 20 cm. of water suction was applied to the drainage arm of the tube. Closed drainage of the chest was maintained for 18 days, at which time expansion of the lung was complete. The tube was removed and no further therapy of the empyema proved necessary.

Meanwhile the patient had developed a large abscess of the abdominal wall which required drainage and also cultured *E. Coli*.

Following these episodes, the patient's improvement was slow but steady. The spur of his ileo-sigmoidostomy was cut down and on the seventieth hospital day the ileo-

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colostomy was closed intraperitoneally. He was discharged on the eighty-fifth hospital day gaining weight and moving his bowels only twice a day. The cavity of the abdominal wall abscess had not entirely healed and required dressing for about 2 weeks after discharge from the hospital.

Follow-up 8½ months after operation revealed that the patient had had no further difficulties. He had gained 40 pounds from his lowest ebb, his wounds were solid, his bowels moved normally once a day.

DISCUSSION

In retrospect, we should have at least suspected the diagnosis of abdominal apoplexy preoperatively. It has been clearly pointed out^{1, 2} that nearly all these episodes have occurred in older males with marked evidence of vascular disease and hypertension. The process develops gradually; there are usually fairly acute abdominal symptoms when the rupture occurs, but the hematoma is at first small and there ensues a period of relative well-being as the hematoma slowly enlarges, during which period the patient feels better but far from well. Finally after several days, in the present case nine days, free rupture into the peritoneal cavity occurs as the hematoma finally enlarges beyond the confines of the mesentery and the patient who has been relatively well is stricken with the symptoms of an acute abdominal catastrophe. This typical symptomatology could well be used as a summary of the present case.

As regards the surgical handling of this problem, a primary anastomosis of the ileum and the remaining colon is theoretically preferable to the Mikulicz type of resection which was used in this case. Dunphy and Whitfield⁴ have emphasized this—a temporary ileostomy is frequently difficult to care for and it commits the surgeon to a further operation on a patient who is a poor risk from the cardiovascular point of view. However, in the present case subsequent events made it very fortunate that a Mikulicz resection had been carried out. There was adequate cause for the patient being seriously ill and had not the infarcted bowel been visible, the second operation would not have been carried out in time, if at all. This emphasizes again that whenever any loop of bowel is exteriorized it must be inspected early and often. It seems probable that the manipulation of the first operation in some way caused the start of thrombosis in the veins of the mesentery of the descending bowel. Certainly the process was well advanced at the time of surgery 36 hours later.

Mesenteric thrombosis occurs much more frequently than abdominal apoplexy, but nevertheless is an uncommon occurrence. Death results from necrosis of the bowel wall, perforation and peritonitis or from hemorrhage into the infarcted bowel with blood loss and shock, or from a combination of these two mechanisms.⁵ Early resection of the involved bowel is the only possible therapy, and this may not be possible because of the extent of the vascular tree and intestinal tract involved. In the present case the thrombotic process was limited to the left colic vein and its branches which made extirpation of the involved bowel readily possible. Once again a primary anastomosis might have been preferable to the Mikulicz procedure but the critical condition of the patient precluded any prolongation of the procedure.

When the *E. Coli* empyema developed it seemed that rib resection and open drainage would become necessary in view of the amount and viscosity of the pus, and it was most gratifying when the empyema completely resolved on closed drainage. It was felt that the amount of saline with which the pleural cavity was irrigated (1200 cc. daily) was an important factor in mechanically washing the pleural space. The antibiotics used could have been introduced in a much smaller amount of fluid, but the large amount of saline used seemed to wash the pleura, dilute the pus and fibrin, and probably was the major factor in keeping the catheter open and functioning without replacement for a period of 18 days.

SUMMARY

A case is presented in which rupture of a branch of the ileo-colic artery necessitated resection of the right colon. This episode was complicated in 36 hours by an entirely different vascular accident, mesenteric venous thrombosis involving the left colon, requiring resection of the descending colon. The patient's course was further complicated by a left total empyema due to *E. Coli* successfully treated by closed drainage. Recovery was complete.

Addendum. The patient was last seen 21 months after the original operation. He had gained ten pounds more and had no complaints referable to his intestinal tract. However, his blood pressure was 250/150. He was suffering from severe headaches and was under the care of the cardiac clinic because of early cardiac decompensation.

We are indebted to Dr. Harlan F. Newton for his help in the management of the empyema in this patient, and to Dr. Joseph Boggs for the pathologic examinations.

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ANEURYSM OF THE SPLENIC ARTERY*

REPORT OF TWO CASES

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ANEURYSM OF THE SPLENIC ARTERY is sufficiently rare to be overlooked in the differential diagnosis of intra-abdominal conditions. Only early diagnosis, before rupture, can prevent a fatality. It is with this in mind that the following two case reports are presented.

CASE REPORTS

Case 1. A white female of 60 years was admitted on April 7, 1947, complaining of vague distressing epigastric pains radiating to the back for several months. Physical examination revealed nothing striking. There was a well-healed upper right rectus scar. A cholecystectomy and appendectomy had been performed 18 years ago. No masses were palpable. All laboratory findings were within normal limits. Abdominal scout films were reported as revealing a circular calcified shadow in the left upper quadrant, representing calcification of the splenic artery (Fig. 1).

A preoperative diagnosis of aneurysm of the splenic artery was made and operation was performed. The spleen was found to be moderately enlarged and adherent to the diaphragm with a firm calcified mass, the size of a walnut, situated in the hilum. The splenic artery otherwise appeared normal. A splenectomy was performed including the removal of the calcified mass in the pedicle. The patient made an uneventful recovery. The pathologic report indicated an arteriosclerotic aneurysm of the splenic artery with congestion of the spleen (Fig. 2).

Case 2. A white female of 60 years was admitted on September 7, 1948, complaining of abdominal pain of 8 days' duration. The pain started in the left upper quadrant, radiated throughout the entire abdomen, and was associated with vomiting at the onset of the present illness. For the past year she had been having some gall-bladder colic. The temperature on admission was 102.6; pulse 90; blood pressure 138/65. Marked pallor was noted. The abdomen was moderately distended, with a tender, ill-defined mass noted deep in the left upper quadrant. Laboratory findings on admission were: hemoglobin 13 Gm., WBC 20,000, polys 70 per cent, bands 15 per cent, myelocytes 3 per cent, lymphocytes 12 per cent. Wassermann negative. Urine negative. Blood chemistry findings were within normal range. Roentgenograms of the abdomen revealed a concentric calcific shadow in the right half, suggestive of an opaque biliary calculus. A barium enema disclosed a normal flow throughout the entire colon with no filling defects.

The patient continued to complain of abdominal pain and ran a moderate fever. At times the mass in the left upper abdominal quadrant was less discernible to some of the observers and it was decided to observe the patient further. On September 23, 1948, she suddenly vomited a large amount of coffee-ground and bloody fluid, passed a profuse quantity of bloody stools and showed signs of shock. Improvement followed immediate transfusion of 1000 cc. of blood. On October 1, 1948, the hemoglobin had declined to 9.0 Gm., R.B.C. 2,200,000; WBC 52,000, polys 68 per cent, bands 16 per cent, lymphs

* Submitted for publication September, 1949.

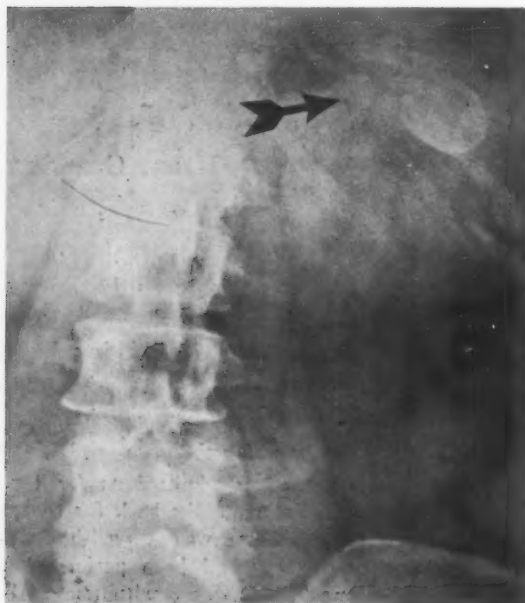


FIG. 1.—Roentgenogram of the abdomen showing the calcified ovoid shadow in the left upper abdominal quadrant suggesting the diagnosis of an aneurysm of the splenic artery. The periphery of this shadow is sharply delineated and the central portion is mottled.

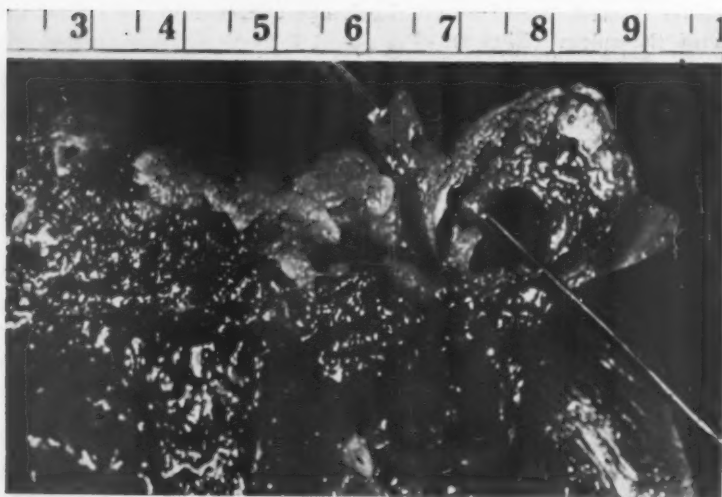


FIG. 2.—Photograph of spleen and the arteriosclerotic splenic artery aneurysm. Probe passes through the splenic artery and the lumen of the aneurysm.

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14 per cent, monocytes 2 per cent. A gastro-intestinal series revealed no evidence of organic lesion of the esophagus or stomach. The duodenal bulb was incompletely filled.

On October 9, 1948, the patient suddenly had another gastro-intestinal hemorrhage with passage of large amounts of bloody and tarry stools and lapsed into deep shock. At this time, marked abdominal distention and tenderness was noted. In spite of blood transfusions she never rallied and expired on October 11, 1948.

Autopsy findings. (Dr. J. Ehrlich) The peritoneal cavity is the site of the main pathology. There is a mass, approximately the size of a grapefruit, located in the lesser sac. This mass consists of a large collection of blood, blood clot and exudate. On

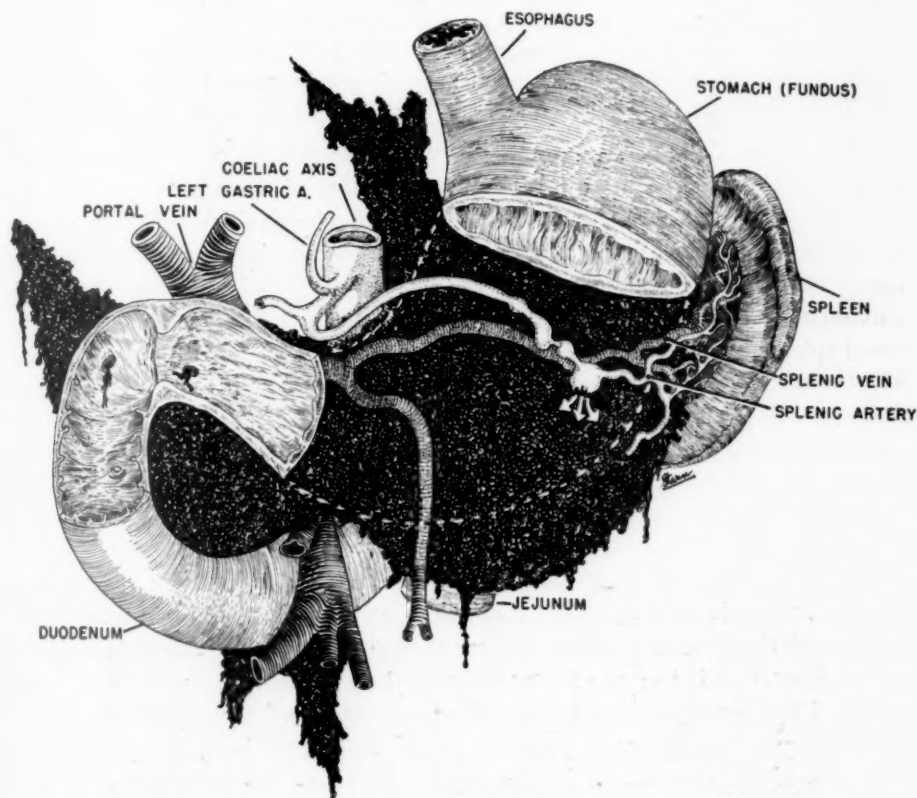


FIG. 3.—Artist's sketch depicting the four small aneurysms of the splenic artery, with rupture of the most distal one. Extensive hematoma of the lesser sac, and the two perforations into the stomach and duodenum through which the exsanguinating gastro-intestinal hemorrhages occurred, are shown.

opening the stomach and duodenum there are found 2 communications; one of these is about $\frac{1}{2}$ inch proximal and the other is about 1 inch distal to the pylorus. Each measures about 5 mm. across and communicates with the retrogastric and retroperitoneal hematoma and exudate. Further dissection discloses many ramifying pockets of extension into the hilum of the liver and lesser sac, the mesentery of the small bowel and the peripancreatic and retroperitoneal tissues. These pockets contain blood clot and purulent exudate. In many areas the walls of these tracts are badly infected and necrotic and there are areas, such as these, which have broken down to establish the communications

with the lumen of the stomach and duodenum. The pancreas is in the infected field and shows several flecks of fat necrosis but does not appear to be primarily involved. The blood vessels in this region appear normal with the exception of the splenic artery. The distal half of this vessel is extremely tortuous, thin walled, and presents 4 aneurysmal dilatations. One of these, the size of a hazel nut, has a large defect over its dome constituting the site of rupture (Fig. 3). The spleen weighs 325 Gm. and has a large infarct on its lower pole. There is also a considerable amount of blood in the small and large intestines.

The sequence of events is probably as follows: The aneurysm of the splenic artery, with slow and leaking rupture, produced a large hematoma in the lesser sac behind and adherent to the stomach. This seeped into the various pockets described. Secondary infection probably followed by way of migration from the bowel into this hematoma, which then ruptured into the stomach and duodenum. Continued bleeding from the ruptured aneurysm developed into exsanguinating hemorrhages by way of the intestinal tract, the blood entering through the perforations in the stomach and duodenum.

Aneurysm of the splenic artery is a rare entity;¹⁻⁴ approximately 144 cases have been reported. The causative factor in most of the cases, as in the two cases in this report, was arteriosclerosis. Although syphilis is considered as a factor in many aneurysms, it was not so considered in any of the reported cases. Mycotic aneurysms of the splenic artery complicating rheumatic valvulitis have been reported. It is of interest to find at least 15 cases of ruptured splenic artery aneurysms complicating pregnancy collected by Cosgrove, Watts and Kaump.⁵ Fourteen of these had a fatal outcome. The correct diagnosis was not made in any of these cases. Those that came to operation were diagnosed as internal hemorrhage associated with the pregnant uterus. At operation, the pregnant uterus must first be emptied by Caesarian section to obtain enough room in the abdominal cavity to seek the bleeding site in the lesser sac.

In most cases of aneurysm of the splenic artery the correct diagnosis is usually not made until autopsy or, at times, at operation. Many are asymptomatic until the time of rupture. Before rupture the complaints may vary from mild epigastric pain to more severe abdominal complaints. Symptoms may suggest gallbladder disease or peptic ulcer. Pressure of the aneurysm on the pancreas may cause some pancreatic insufficiency and be manifested by the presence of undigested fat in the stool. In most instances there is some enlargement of the spleen with infarction. Roentgen ray examination may at times aid in the diagnosis. When there is sufficient calcification in the wall of the aneurysm, it will appear as a calcified shadow in the left upper quadrant of the abdomen. It usually is depicted as an oval shadow with the periphery sharply delineated and the central portion presenting a mottled appearance. In some, a pulsation may be felt or a bruit heard in the left upper abdomen and thus suggests the diagnosis.⁶

After rupture the picture may simulate any acute abdominal condition with signs of profound shock due to exsanguinating hemorrhage. Brockman⁶ expressed the opinion that rupture takes place in two stages. First, rupture occurs slowly into the lesser sac with formation of adhesions to the surrounding viscera. Later, secondary rupture occurs with severe hemorrhage

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into the general peritoneal cavity through the foramen of Winslow in most cases, or at times rupturing into the stomach or colon. This secondary rupture with hemorrhage is usually followed by death.

The mortality rate is extremely high after rupture of an aneurysm of the splenic artery. There are few recorded cases of survival after operation. In 1947, Dobson, Morse and Covert⁷ reported the fifth survival in 20 cases operated on after rupture. The importance of diagnosis and operation before rupture is obvious. Davis⁸ in 1925 reported the first case of successful treatment of an unruptured splenic artery aneurysm by ligation of the afferent and efferent portions of the splenic artery with removal of the aneurysm. After rupture, the procedure is a much more hazardous one. The patient is in very poor condition, bleeding actively, and the technical surgical procedure may be too much to carry out in the presence of a large hematoma mass in the lesser sac, with dense adhesions to the stomach and colon.

Treatment. The procedure of choice is splenectomy with removal of the aneurysm. If that is not feasible, then proximal ligation of the splenic artery in continuity or with interruption may be considered. Ligation of the splenic artery is usually followed by aseptic atrophy of the spleen and is without any ill effects. Tamponade is ineffectual when the aneurysm has ruptured; it has always resulted in a death.

SUMMARY AND CONCLUSIONS

1. Two cases of aneurysm of the splenic artery are reported. One, unruptured, was diagnosed by roentgen ray and treated successfully by splenectomy and removal of the aneurysm. The second case was not diagnosed before death of the patient. Postmortem examination showed a ruptured splenic artery aneurysm with an extensive, infected hematoma in the lesser sac and a secondary rupture into the intestinal tract. These had resulted in exsanguinating hemorrhage and death. The causative factor in both was arteriosclerotic changes in the vessel wall.

2. The importance of making the diagnosis of splenic artery aneurysm before rupture, and of operating to prevent the tragedy of rupture is emphasized.

3. Operative treatment is the only possible hope after rupture of the aneurysm.

4. The value of auscultation in the examination of the abdomen is mentioned.

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SIMPLIFIED DERMATOME FOR SPLIT THICKNESS GRAFTS*

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THIS INSTRUMENT was originally designed to be used by the surgeon who only occasionally cut small split thickness skin grafts, and to whom a Padgett-Hood dermatome was not available. Subsequently, for all small split grafts, the simplified dermatome was found to be easier to use and to require consid-

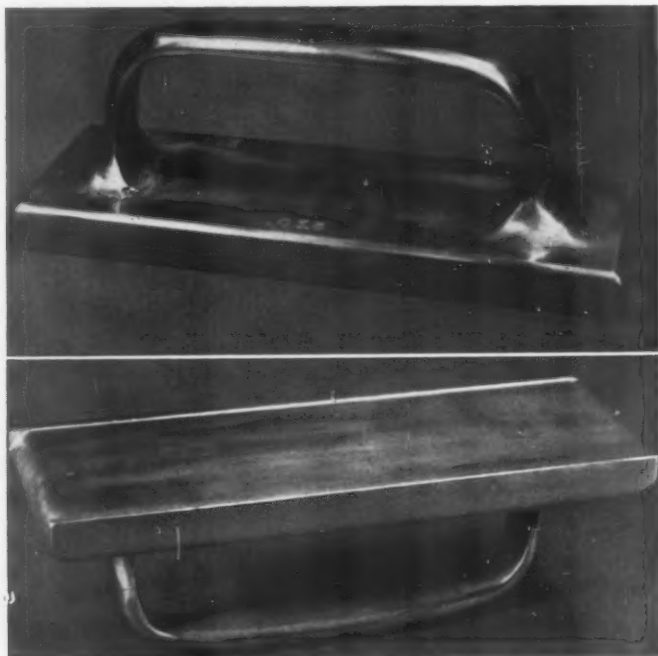


FIG. 1.—In the lower view of the face plate of the simplified dermatome, note raised edges on sides.

erably less operating time than the adjustable dermatome. The disadvantages of the simplified dermatome are: (1) Depth of cut is pre-determined and cannot be altered, and (2) the amount of skin removed per cut cannot be varied except within narrow limits.

* Since the instrument herein described makes use of an adhesive to lift the skin, it would constitute infringement of the patents under which the Padgett-Hood Dermatome is licensed for anyone to make or use this instrument without permission of the holders of the patent rights. Submitted for publication April, 1949.

DERMATOME FOR SPLIT THICKNESS GRAFTS

As shown in Figure 1, the instrument is a flat plate with a handle. The base measures $\frac{3}{8}$ by 2 by 4 inches and ridges $\frac{1}{16}$ inch wide are raised on either side. The height of the ridges, which determines the thickness of the graft, was .010 inch on the original instrument and since then a set of three more have been made with ridges .008, .012, and .016 inches. Chrome plated brass has been used.

The flat surface of the instrument and the skin are prepared as for any dermatome graft, with care to insure adequate thinning of the glue. The skin and face plate are pressed together firmly for one minute. The plate is then elevated, which raises the attached skin. A Smith-Feris knife or a straight razor is pressed firmly along the ridges as the skin is cut with a slicing motion. The 2 by 4 inch split thickness graft is then cut from the intact skin. The graft is applied as usual.

The following cases illustrate use of the simplified dermatome.

W. H. was burned on the left hip when his gasoline-soaked pants caught on fire. Tannic acid ointment was applied and he had no other treatment until admission three days later. Examination showed an exquisitely tender circular eschar, about 4 inches in diameter, on the left hip. The eschar was excised completely and a split thickness graft was applied. A complete take with prompt healing was obtained.

O. L. was thrown through a window, and received several cuts on the left hand, including complete denuding of the flexor surface of the ring finger. He was admitted 18 hours after the accident. In view of the time elapsed, a split thickness graft rather than a pedicle graft was thought best because of the risk of infection. Under local procaine infiltration a split thickness graft was applied to the denuded area of the ring finger. A 95 per cent take with good healing and excellent function followed.

H. L. T., an 11-year-old schoolboy, received a flame burn on the lower abdomen and upper thigh at the age of three years. Treatment consisted of bed rest. He subsequently developed a scar contracture from the inguinal region to the upper thigh which prevented complete extension of the thigh by 30 degrees. Under ether anesthesia the scarred area was removed, and flaps swung so as to close the denuded area as much as possible. This left an area roughly 2 by 4 inches over which a split thickness graft was placed. The area healed well and full extension was possible on discharge. His course was prolonged by infection of the donor site.

Editorial . . .

ANESTHESIA AND THE OLD-TIME SHOTGUN PRESCRIPTION

THE OTHER DAY we had a visitor who described current practices in his well-known department of anesthesia: First, spinal anesthesia is produced and then the patient is put to sleep with "a little" pentothal sodium. Cyclopropane is started and "a little" curare is injected. Then a syringe of cocaine is squirted *through* the neck into the trachea to give topical anesthesia of the airway and an endotracheal tube is inserted. An intravenous "trickle" of procaine is started and "a little" ether is added.

It may be fair to call this an extreme example, and extreme it is, but unfortunately this, or something like it, is not uncommon. This, in short, is polytherapy and it is rather like the old-time shotgun prescription, conceived in hope, but based on very little data.

What are the reasons for it? Well, for one thing, there is the belief that change is a synonym for progress. There is the honest anesthetist's hope that by some delicate alchemy he can pile up the good qualities of several useful agents and with mysterious good luck avoid piling up their bad qualities too, and thus achieve a perfection not otherwise possible. There is man's understandable love for the spectacular, the long shot, the gambler's chance, based upon the hope that by doing something differently he can make an important discovery. The end-result of this is that at a time when surgeons are simplifying their technics, anesthetists are elaborating theirs, without adequate reason.

A mistaken concept may lie at the bottom of this use of many drugs: Surgery is a complex field, filled with difficult technics. It can attract good men by the challenge of the technics involved. Anesthesia, on the other hand, has no comparable technical richness; but the polytherapists, failing to look squarely at reality, perhaps believe they can legitimately make anesthesia complicated enough to attract able men on this technical basis. Men of action and vigor are entering the field and seeking an outlet for their energies, an outlet, in this case, which is almost certainly a blind alley. In some cases, it must be admitted, this polytherapy is the result of a bold attempt to gain prestige in a milieu where technics are glorified. Somewhere a line is crossed and courage becomes rashness.

Anesthesia *has* richness as a field for study, and has resources, but not great ones, in its clinical technics; but anesthesia's appeal to able men lies in its unsolved problems. To the curious and the thoughtful there is a stirring challenge here.

Why is it bad? The needless use of many drugs is bad because each agent's thorny bad qualities cannot be dissociated from its good ones. The accumulated good qualities of many agents may offer real advantage over the

combined good qualities of one or two agents. The cumulative bad qualities of several agents can add up to disaster. It is difficult enough to perceive adequately the warning signs of toxicity of one or two agents. When many agents are used, a difficult job becomes impossible. And when an accident occurs under such circumstances it is usually impossible to discover which agent was responsible. So experience can teach but little and errors are perpetuated.

The piling up of many anesthetic agents is not necessary for safe and satisfactory surgery, but in time good surgeons may be deluded into believing that it is.

In some well-known clinics the residents in anesthesia never have an opportunity to see any simple technics. The sound tradition of training a man with one agent at a time is lost. Current multiple drug practices are not based upon careful, controlled evaluation but too often on hunches. Where else in medicine do we leave so much to the unchecked hunch?

Trial of reasonable combinations of drugs is of course desirable on a controlled experimental basis with objective justification or rejection as the goal; but the difficulties of such complex studies are of course very great. In the current situation the approach is too often uncritical and too often uncontrolled.

Finally, it can be observed that the analogy with old-fashioned polytherapy made above fails in a significant respect; the old-time physician was often dealing with relatively harmless substances. The modern-day anesthetist's concoction contains agents with deadly potentialities.

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EDITORIAL ADDRESS

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BOOK REVIEW

THE MODERN MANAGEMENT OF GASTRIC AND DUODENAL ULCER. F. Croxon Deller, Ed., Williams, Wilkins and Co., Baltimore, 1948. List of contributors: H. C. H. Bull, R. Sleigh Johnson, J. Alfred Lee, Rodney Maingot, and A. K. Monroe.

This volume presents, in a clear, careful and detailed manner, practically all sides of the treatment of peptic ulceration of the stomach and duodenum. The discussion is very complete. Although the entire book is excellent, the reviewer was particularly impressed by the meticulous care with which emphasis was placed upon thorough analysis and the importance thereof of the diagnostic features of ulceration. The relative importance of the various means of diagnosis and their interdependence and variation has been well and carefully discussed. Medical treatment is properly and detailedly emphasized; there are discussions concerning estimates of failure of medical treatment, and the indications for surgery are fairly stated and analyzed. Careful separation of gastric and duodenal ulcer in the discussion of indications for surgery is maintained. Emphasis is placed upon the lack of reliability of the signs of healing in gastric ulcer, and the disastrous result which may follow failure to carefully check this point was repeatedly emphasized. The role of surgery in the treatment of ulcer, as only a part in the treatment of such patients, was well brought out. The chapters on technic were complete and well illustrated.

There were a few points which the reviewer felt might have been expanded. In the medical treatment, little was said of the newer non-alkalinizing and non-ionizing amorphous substances, which, in America at least, have been replacing alkaline therapy. The discussion of the role of surgery in bleeding might have been expanded, with more emphasis laid upon the specific patient believed best treated by emergency gastrectomy for exsanguinating hemorrhage.

The thorough, fair and sympathetic treatment given to all the details in this book make it an admirable treatise.

JOHN T. REYNOLDS, M.D.

BOOKS RECEIVED

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Ulcers and Eczema of the Leg, Sequels of Phlebitis, Etc. Einar Munksgaard, Copenhagen, Denmark, 1948.

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